PROCEEDINGS

OF THE

ROYAL IRISH ACADEMY.

Second Series.

VOLUME III.—SCIENCE.

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desire it to be understood, that they are not
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f the several Parts forming Volume III.,
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OCEEDINGS

OF

L IRISH ACADEMY.

SCIENCE.

D BEFORE THE ACADEMY.

CAPTURED IN THE SEYCHELLES ISLANDS, by
AL WRIGHT, M. D., F. L. S.; WITH DESCRIP-
PPOSED TO BE NEW TO ARACHNOLOGISTS, by
L. S. Notes and Preface, by the REV. O. P.
. M. Z. S., &c. Plates 1 & 2.

ead, November 13, 1876.]

ns of Seychelles Spiders were prepared by
all, rather more than six years ago. Their
oidably delayed, and a request has been made
Vright (with Mr. Blackwall's kind assent) to
ch annotations as the progress of Araneology
t seem to require. In doing this, I have
essed by Mr. Blackwall; and that is, typical
allied species for comparison with the types
Wright) from which Mr. Blackwall's descrip-

lance with the systematic arrangements now
re, of course, not altered that which Mr.
the present list, and which he himself esta-
a strong grounds of, at least practical, conve-

nience. In order, also, not to alter nor mutilate his wonderfully lucid and minute descriptions, I have included such observations as seemed requisite, in a different type, and within brackets, chiefly at the end of the several descriptions of those species to which the observations apply.

O. P. CAMBRIDGE.

BLOXWORTH, DORSET,
September 19*th*, 1876.]

Tribe OCTONOCULINA.

Family SALTICIDÆ.

Genus SALTICUS, *Latr.*

SALTICUS WRIGHTII, n. sp. [Attus, Sim.]. Plate 1, fig. 1.

Length of the female (not including the spinners) $\frac{3}{10}$ths of an inch; length of the cephalothorax, $\frac{3}{20}$; breadth, $\frac{1}{10}$; breadth of the abdomen, $\frac{1}{12}$; length of an anterior leg, $\frac{4}{15}$; length of a leg of the third pair, $\frac{1}{4}$.

The minute intermediate eye of each lateral row is nearer to the anterior than to the posterior eye of the same row. The cephalothorax is large, glossy, and somewhat quadrilateral; it slopes abruptly at the base, has a broad indentation in the medial line, and is of a dark reddish-brown colour, with a broad, curved, brownish-red, transverse band near the middle, whose convexity is directed backwards, and a transverse bar of the same hue between the anterior and posterior eyes. The falces are powerful, conical, slightly prominent, divergent at the extremity, and armed with a few teeth on the inner surface. The maxillæ are strong, straight, and enlarged at the extremity, which is obliquely rounded on the inner side; and the lip is oblong, and rounded at the apex. These parts are of a reddish-brown colour, the extremity of the maxillæ and the apex of the lip having a yellowish-white hue. The sternum is oval, with slight prominences on the sides, opposite to the legs; the posterior is broader than the anterior extremity, and its colour is yellowish-white. The legs are robust, especially those of the anterior pair; they are provided with hairs, and the first and second pairs have two parallel rows of spines on the inferior surface of the tibiæ and metatarsi; the anterior legs are of a reddish-brown colour, with the exception of the tarsi, which have a brownish-yellow hue; the colour of the first, second, and third pairs is brownish-yellow, that of the sides of the femora being brown; the first pair is the longest, then the second, and the third pair is the shortest; each tarsus is terminated by two curved, minutely pectinated claws, below which there is a small scopula. The palpi are slender, of a brownish-yellow hue, and the digital joint is supplied with long hairs. The abdomen is long, subcylindrical, and tapers to the spinners, which are prominent, the superior pair being the longest; a broad yellowish-white band,

slightly sinuous, extends along the middle
anterior part, contiguous to the cephalotho-
a dark-brown colour; a yellowish-white line
om the posterior half of which two streaks of
d obliquely backwards and downwards; the
ish-white colour, with a short, transverse,
mers, which have a dark-brown hue, their
ing yellowish-white: the sexual organs are
d of a brownish-red colour.

ais prettily marked Salticus the name of Pro-
t, who, on various occasions, has transmitted
collections of foreign spiders, and has most
describe such species as were supposed to be
ts.

. [Attus, Sim.]. Plate 1, fig. 2.

(not including the spinners) $\frac{3}{16}$ths of an
alothorax, $\frac{1}{15}$; breadth, $\frac{1}{16}$; breadth of the
leg of the third pair, $\frac{3}{16}$; length of a leg of

s convex, glossy, somewhat quadrilateral,
the front, and abruptly at the base; it has
en the posterior pair of eyes, is sparingly sup-
and is of a yellowish-red colour; the cephalic
with brown, especially about the lateral eyes.
ach side of the posterior slope, and the frontal
long yellowish-white hairs. The minute in-
teral row is nearly equidistant from the eyes
es. The falces are short, subconical, vertical,
eeth on the inner surface; the maxillæ are
nd rounded at the extremity; the lip and
ter being broader at the posterior than at the
legs are robust, especially those of the an-
ded with hairs and spines, two parallel rows
the inferior surface of the tibiæ and meta-
nd pairs; the third pair is the longest, then
pair slightly surpasses the second; each tar-
curved, minutely pectinated claws, below
scopula; the palpi are short, and the radial
ll supplied with pale hairs. These parts are
, the falces being the darkest. The abdomen
and tapers to the spinners, which are pro-
ith pale hairs, and is of a yellowish-white
being the palest; an irregular brown band
f the upper part, and the space between these
of rather obscure angular and curved lines of
band, consisting of short brown streaks and
nterior extremity, and passes obliquely down-

B 2

wards; the sides are marked with oblique lines composed of short brown streaks, and there is a triangular spot of a similar colour directly above the coccyx; a minute brown spot is situated immediately before the spinners on the under part, and the sexual organs, which are well developed, are of a dull reddish-brown colour.

The male bears a general resemblance to the female, but differs from her in various particulars. Its cephalothorax, which is darker coloured, has a patch of hairs before the medial depression, a smaller one behind each large anterior eye, and a broad band curved from its anterior margin across the middle of the posterior slope; these patches and the band have a white hue, and there are a few long black bristles situated below the small intermediate eye of each lateral row. The large anterior eyes are of a bright green hue, and are encircled by short white hairs. The falces have some white hairs at their base, and with the base of the maxillæ and lip are of a brown-red colour. The extremity of the femora, the genua, and the tibiæ of the first and second pairs of legs are of a red-brown colour, the inferior surface being the darkest; and the third and fourth pairs are marked with annuli of the same hue. The radial joint of the palpi is smaller than the cubital, and has a pointed adophysis directed forwards from the outer side of its extremity. The digital joint is oval, hairy, convex above, and comprises in its concavity the palpal organs, which are moderately developed, not very complex in structure, with a pointed spine curved round their extremity from the inner to the outer side, and are of a reddish-brown colour. The abdomen is slender, and the irregular brown band that extends along each side of the upper part in the female is usually more or less broken into spots in the male, and the superior spinners have a brown streak on their upper surface.

SALTICUS ACTIVUS, n. sp. [Heliophanus, C. L. Koch]. Plate 1, fig. 3.

Length of the female (not including the spinners), $\frac{1}{5}$th of an inch; length of the cephalothorax, $\frac{1}{12}$; breadth, $\frac{1}{16}$; breadth of the abdomen, $\frac{1}{16}$; length of a posterior leg of the second pair, $\frac{1}{12}$.

The minute intermediate eye of each lateral row is nearly equidistant from the eyes constituting its extremities. The cephalothorax is convex, glossy, somewhat quadrilateral, with a slight indentation in the middle, and is provided with short whitish hairs; it slopes gradually towards the front, abruptly at the base, and its predominant colour is red-brown; the cephalic region has a dark-brown hue, and a line of white hairs extends along each side above the lateral margin. The falces are short, subconical, vertical, and armed with one or two small teeth at the extremity; the maxillæ are straight, and enlarged and rounded at the extremity; and the lip is oval. These organs are of a red-brown colour, the falces being the darkest, and the extremities of the maxillæ and lip the palest; the sternum is oval and rather broader at the posterior than at the anterior extremity. The legs are moderately strong, provided with hairs and spines, two parallel rows of the latter occurring on the inferior surface of the tibiæ

rominent, and is clothed with pale hairs; are of a brown colour, the former being te. A yellowish-white band, which curves ty, and extends along the sides, projects e from its inner margin, on each side, the rming a transverse band about a third of rs; the under part is of a yellowish-white wn bar before the spinners; and the sexual have a dark reddish-brown hue.

l much darker coloured than the female. n hue, and the humeral joint has a pointed e under side, which is curved downwards; oblong oval form; it is convex above, h hairs, compact at the extremity, with a t comprises the palpal organs, which are or complex in structure, and are of a dark-

that this spider is the *Attus lugubris* of le la Réunion, &c., p. 50, Pl. x., fig. 7), and inly identical with the *Attus variabilis* of mples from which Mr. Blackwall's descrip- lour and lustre considerably, but the abdo- nct in both sexes. The humeral joint of the Mr. Blackwall) is armed with the pointed of the genus Heliophanus.]

. sp. [Salticus, Sim.]. Plate 1, fig 4.

e female, $\frac{1}{6}$th of an inch; length of the , $\frac{1}{24}$; breadth of the abdomen, $\frac{1}{24}$; length h of a leg of the second pair, $\frac{1}{..}$

falces are short, subconical, slightly prominent, and are armed with a few minute teeth on the inner surface; the maxillæ are straight, and enlarged and rounded at the extremity; the lip is longer than broad and rounded at the apex; the sternum is long and narrow, and has slight eminences on its sides, opposite to the legs. The legs are slender, provided with hairs, and have two curved claws at the extremity of each tarsus, below which there is a small scopula; the fourth pair is the longest, then the third, and the second pair is the shortest; the palpi are short, and the digital joint is somewhat enlarged at its extremity. These parts are of a yellowish-white hue, the falces and lip having a slight tinge of red, and the genua and tibiæ of the first pair of legs have a pale-brown line extending along their anterior surface. The abdomen is oviform, glossy, thinly clothed with pale hairs, and is connected with the base of the cephalothorax by a long slender pedicle; it is strongly constricted about one-third of its length from the anterior extremity, and is of a pale yellowish-brown colour, a transverse band before and after the constriction, and the branchial opercula having a brown hue.

Family LYSSOMANIDÆ.

The spiders of this family are most nearly allied to those of the family Salticidæ, but they differ from them decidedly in the form of the cephalothorax, the disposition of the eyes, the figure of the maxillæ, of the lip, and sternum, and also in the structure of the spinners, the superior pair having the spinning-tubes arranged on the inferior surface of the pointed terminal joint. These marked differences in their external organization, indicating a corresponding modification of habits and economy, have induced me to propose for their reception a family distinct from that of the Salticidæ.

Genus LYSSOMANES, *Hentz.*

[Although the genus Lyssomanes (Hentz) is an exceedingly distinct and remarkable one, there appears to be nothing to warrant its separation from the Salticides, with which its general form and characters show it to be unmistakably allied. The example from which Mr. Blackwall's description is made had apparently not long cast its skin, so that its colourless condition is probably not that which belongs to the adult form.]

LYSSOMANES PALLENS, n. sp. Plate 1, fig. 5.

Length of an immature male (not including the spinners), $\frac{1}{5}$ of an inch; length of the cephalothorax, $\frac{1}{16}$; breadth, $\frac{1}{18}$; breadth of the abdomen, $\frac{1}{20}$; length of a posterior leg, $\frac{1}{4}$; length of an anterior leg, $\frac{1}{16}$.

The colour of this spider is white tinged with yellow, particularly on the sides and base of the cephalothorax. The eyes are disposed on the anterior part of the cephalothorax; two, which are situated in

est, and are prominent, pellucid, and almost
f the upper part of the cephalic region three
orm of an irregular triangle, on small tuber-
black spots, the intermediate eye, constitut-
se angle, being the smallest of the eight.
mewhat quadrate, convex, glossy, slightly
at the base, and moderately elevated in the
lces are small, subconical, and inclined to-
ch is broad, convex, and heart-shaped; the
ed at the extremity, and inclined towards
hat quadrate, being broader at the base than
re slender, and provided with hairs and long
of the latter extending along the inferior
metatarsi of the first and second pairs; each
wo minute, curved claws, below which there
The abdomen is long, subcylindrical, and
rs distributed over its surface. The superior
, and their terminal joint, which is pointed,
ranged on its inferior surface. The palpi of
the description was made were very timid,
re not developed, indicating that it probably
change of integument before it arrived at
s stronger than the cubital joint, and promi-

amily THOMISIDÆ.

enus THOMISUS, *Walck.*

n. sp. [Xysticus, Koch]. Plate 1, fig. 6.

e, $\frac{8}{25}$ths of an inch; length of the cephalo-
breadth of the abdomen, $\frac{1}{12}$; length of an an-
a leg of the third pair, $\frac{1}{10}$.

d on the anterior part of the cephalothorax in
rows, forming a crescent whose convexity is
eyes of each lateral pair are larger than the
re seated on tubercles united at their bases,
the largest, and the intermediate eyes of the
st of the eight. The cephalothorax is convex,
essed before, truncated in front, rounded on
essed at the base, and has a few fine bristles
its anterior margin; its colour is red-brown,
nd yellowish-brown; it is darkest on each side
d the lateral margins are black; a broad band,
e eyes along the middle to its base, is of a
in the cephalic region, and is strongly tinged
ior slope, at the commencement of which it is
the anterior part of the band comprises two
whose pointed anterior extremities extend to

the posterior intermediate eyes, between which there are two short confluent streaks of the same hue. The falces are short, cuneiform, vertical, and of a red-brown colour, being palest at the base, in front, where there is an irregular yellowish-white spot. The maxillæ are obliquely truncated at the extremity, on the outer side, and inclined towards the lip, which is triangular, but rounded at the apex. These parts are of a red-brown colour, their extremities having a yellowish-brown tint. The sternum is heart-shaped, glossy, and of a pale-yellow hue. The legs are provided with hairs and spines, two parallel rows of the latter occurring on the inferior surface of the tibiæ and metatarsi of the first and second pairs, and a few conspicuous ones on the anterior side of the former; they are of a pale red-brown hue, with yellowish-white annuli more or less perfectly formed, those on the base of the third and fourth pairs being much the broadest; the first and second pairs, which are longer and more robust than the third and fourth pairs, are equal in length, and the third pair is the shortest; each tarsus is terminated by two curved, minutely pectinated claws. The palpi, which are short and slender, resemble the legs in colour, and have a small curved claw at their extremity. The abdomen is oviform, moderately convex above, projecting a little over the base of the cephalothorax, and has a few short hairs distributed over its surface; it is of a whitish hue, with a large dark-brown band, freckled with minute white spots, extending along the middle of the upper part to the coccyx; this band is irregular in outline and broadest about the middle; it then tapers to its extremity, which has a tinge of red, and projects short parallel streaks from each side; a white line, which passes from the anterior part of the band along the middle, is crossed near its extremity by two short curved lines of the same hue, and is followed by two white spots, the anterior one being the larger; the band also comprises five depressed dark-brown spots; the three anterior ones describe an angle whose vertex is directed forwards, and the other two are parallel to its base; the sides are marked with dark-brown confluent spots that form oblique rows; a pale-brown band, which tapers to its extremity, extends from the yellow branchial opercula along the middle of the under part to the spinners, the superior and inferior pairs of which organs are spotted with black at the base; the sexual organs are well developed, and have a pale red-brown hue.

Genus Olios, *Walck.*

Olios validus, n. sp. [Isopeda, L. Koch]. Plate 1, fig. 7.

Length of the female, $1\frac{3}{16}$ inch; length of the cephalothorax, $\frac{7}{16}$; breadth, $\frac{5}{16}$; breadth of the abdomen, $\frac{11}{24}$; length of a leg of the second pair, $2\frac{6}{16}$; length of a leg of the third pair, $1\frac{3}{16}$.

The eyes are disposed on the anterior part of the cephalothorax in two transverse nearly parallel rows, the anterior row, which is the shorter, being situated immediately above the frontal margin; the

four intermediate eyes form a square, and those of each lateral pair are placed obliquely and wide apart on a tubercle; the anterior lateral eyes are the largest, and the posterior intermediate ones the smallest of the eight. The cephalothorax is large, convex, glossy, slightly compressed before, truncated in front, rounded on the sides, and has an indentation in the medial line of the posterior region; it is clothed with short dull-yellowish hairs, and has a red-brown hue, the anterior part being the darkest. The falces are powerful, conical, slightly prominent, somewhat divergent at the extremity, armed with teeth on the inner surface, and have some long yellowish hairs in front; the maxillæ are strong, rounded at the extremity, and curved towards the lip, which is somewhat quadrate, being broader at the base than at the apex. These parts are of a brownish-black colour, the extremity of the maxillæ and the apex of the lip having a tinge of red; the latter and the extremity of the falces on the inner side are densely fringed with long bright-red hairs; the sternum is heart-shaped, and of a red-brown colour. The legs are long, robust, provided with hairs and strong sessile spines, and are of a red-brown colour; the second pair is the longest, then the first, and the third pair is the shortest; each tarsus is terminated by two curved, pectinated claws, and the anterior part of the tibiæ and the metatarsi and tarsi are supplied with dark-brown scopulæ on the inferior surface. The palpi resemble the legs in colour; the digital joint, which is the darkest, is supplied with numerous short hairs, and has a small, curved, pectinated claw at its extremity. The abdomen is oviform, pointed at the spinners, convex above, and projects over the base of the cephalothorax; the upper part is clothed with short hairs, some long ones of a yellowish hue being interspersed; it is of a brown colour, and has a short, transverse, yellow bar at its anterior extremity; the under part is black; a broad transverse, orange-coloured band, comprising the branchial opercula and sexual organs, occurs at its anterior extremity, and from each of the branchial stigmata a fine yellowish-white line passes nearly to the spinners. The sexual organs are moderately developed, somewhat oval in form, and of a red-brown colour.

The male is smaller than the female, and its legs are much more slender; it is rather lighter coloured also, and the extremity of its abdomen, on the under side, has also an orange hue. The radial, which is a little longer than the cubital joint of the palpi, has a long spine directed forwards from each side of its base, and projects a strong and somewhat pointed black apophysis from its extremity, on the outer side; the digtial joint has an oblong-oval form, and brown colour; it is convex and hairy externally, concave within, comprising the palpal organs, which are well developed, complex in structure, with a strong process curved round the base to the inner side, and their colour is an intermixture of very dark and light red-brown.

[The genus Olios, Walck. (Sarotes, Sund.) being found incapable of including a large number of gigantic Thomisidæ of this group, discovered

lately (especially in Australia), these spiders have been subdivided into several more or less well-marked genera by Dr. T. Thorell, and Dr. L. Koch; to one of these genera, Isopeda (L. Koch), the fine spider above described appears to belong. The genus Sarotes, Sund., now comprises a restricted group, of which the type is the widely dispersed and common species *S. regius*, Fabr. = *Olios leucosius*, Walck.]

Genus Sparassus, *Walck.*

Sparassus guttatus, n. sp. [Leiocranum, L. Koch]. Plate 1, fig. 8.

Length of an immature female, $\frac{1}{6}$th of an inch; length of the cephalothorax, $\frac{1}{16}$; breadth, $\frac{1}{16}$; breadth of the abdomen, $\frac{1}{18}$; length of an anterior leg, $\frac{1}{4}$; length of a leg of the third pair, $\frac{1}{6}$.

The eyes, which are seated on black spots, are disposed on the anterior part of the cephalothorax in two slightly curved, nearly parallel rows, the posterior row being rather the longer; the four intermediate eyes form a square; the two anterior ones are the largest and darkest coloured of the eight, and the two posterior ones are the smallest. The cephalothorax is convex, glossy, compressed before, rounded in front and on the sides, depressed at the anterior part, abruptly so at the base, and has an indentation in the medial line of the posterior region; it is of a brownish-yellow colour, with narrow, dark-brown lateral margins; a short line is directed backwards from each eye of the posterior row, and a fine one passes obliquely backwards from the extremity of each exterior line till it comes in contact with a medial line whose anterior extremity is the finer, and the sides are marked with spots and short streaks; these lines, streaks and spots are of a brown colour. The falces are conical, vertical, and armed with a few small teeth at their extremity; the maxillæ are short, rounded at the extremity, and slightly inclined towards the lip, which is broader than long and somewhat quadrate; and the sternum is broad, convex and heart-shaped. These parts are of a yellowish-white colour, and the falces, which are rather the darkest, have an oblong brown spot at their base, in front. The legs are slender, and do not differ greatly in length; they are provided with hairs and long sessile spines, two parallel rows of the latter extending along the inferior surface of the tibiæ and metatarsi of the first and second pairs, and are of a dull-yellowish colour, tinged with brown, the metatarsi of the posterior legs having a dark-brown annulus at their base and extremity; the first pair is rather the longest, the fourth pair slightly surpasses the second, and the third pair is the shortest; each tarsus is terminated by two curved, minutely pectinated claws, below which there is a small scopula. The palpi resemble the legs in colour, and have a slender, curved, slightly pectinated claw at their extremity. The abdomen is oviform, pointed at the spinners, moderately convex above, and projects a little over the base of the cephalothorax; it is of a

yellowish-white colour, the under part being the palest; the sides are freckled with small brown spots, and there is a series of spots of a similar hue, having an angular form and somewhat larger size, that extends along the middle of the upper part, but is not continued to its extremities; two large black spots occur on each side of the under part; the anterior ones comprise the branchial opercula, and the posterior ones, which are the largest, are pointed at their posterior extremity.

I have felt some difficulty in assigning a place to this spider in the family Thomisidæ, to which its immature state has in some measure contributed. In several particulars, and especially in the figure of its lip, it resembles certain species belonging to the genus Olios, but I have been induced by its predominant characteristics to include it, provisionally, in the genus Sparassus.

[Whatever this spider may be, it is certainly not a Sparassus, and, in spite of a very laterigrade appearance, it probably belongs to the Drassides rather than to the Thomisides. I have a very nearly allied, though distinct (and as yet undescribed), species of the genus to which it belongs, from Ceylon. Dr. Ludwig Koch, to whom I forwarded examples of the Ceylon species, says they are certainly of the family Drassides, and, in his opinion, of the genus Leiocranum, L. Koch.

It will probably be necessary to found a new genus upon these spiders, differing, as they do materially, from the typical Leiocranum, into which genus I cannot at all fit them. In giving the above opinion I am supported by the difficulty felt by Mr. Blackwall in regard to assigning this spider a place in the family Thomisides, and by his placing it, provisionally only, in the genus Sparassus—(see the remarks at the end of his description).]

Family DRASSIDÆ.

Genus CLUBIONA, *Latr.*

CLUBIONA NIGROMACULOSA, n. sp. Plate 2, fig. 9.

Length of an immature female, $\frac{5}{24}$ths of an inch; length of the cephalothorax, $\frac{1}{10}$; breadth, $\frac{1}{12}$; breadth of the abdomen, $\frac{1}{16}$; length of a posterior leg, $\frac{5}{16}$; length of a leg of the third pair, $\frac{1}{3}$.

The abdomen is oviform, pointed at the spinners, which are prominent, thinly clothed with white hairs, moderately convex above, projecting over the base of the cephalothorax, and is of a pale-yellowish colour; a series of six small black spots, disposed in pairs and almost contiguous, extends from the anterior extremity of the upper part along the middle nearly half of its length, and is followed by a series of eight very minute spots of the same hue, also disposed in pairs, but

separated by distinct intervals; these series are comprised between two rows of black spots, which converge towards the spinners, two of them, on each side, being confluent with those of ultimate and penultimate pairs of the intermediate series of minute spots; a few very minute black spots also occur on the posterior half of each side. The eyes are seated on black spots, and form two transverse rows on the anterior part of the cephalothorax; the anterior row, which is the shorter and straight, is situated immediately above the frontal margin; the posterior row is slightly curved, having its convexity directed upwards, and the interval between the intermediate eyes is greater than that which separated them from the lateral eyes of the same row; the four intermediate eyes describe a trapezoid, the two anterior ones, which form its shortest side, being rather the largest of the eight. The cephalothorax is oval, rounded in front and on the sides, convex, glossy, with a very slight narrow indentation in the medial line of the posterior part; it is of a dull-yellow colour, with a fine, irregular, brown line on each side of the cephalic region. The falces are conical, rather prominent, and armed with a few small teeth on the inner surface; the maxillæ are enlarged and somewhat divergent at the extremity; the lip is oblong, and broader at the base than at the apex, which is rounded; the sternum is oval, with small prominences on the sides, opposite to the legs. The legs are long, and provided with hairs and sessile spines, dark-coloured hair-like papillæ occurring on the inferior surface of the metatarsi and tarsi of the first and second pairs; the fourth pair is the longest, then the second, and the third pair is the shortest; each tarsus is terminated by two curved, pectinated claws, below which there is a small scopula; the palpi are short, and the digital joint is well supplied with hairs, which give it the appearance of being somewhat enlarged, particularly at the extremity. These parts have a pale-yellowish hue, the cephalothorax being rather the darkest.

Family CINIFLONIDÆ.

Genus Orithyia, *Blackw.* [Uloborus, *Walck.*]

Orithyia Williamsii.

Orithyia Williamsii, *Blackw.*, *Ann. and Mag. of Nat. Hist.*, ser. 3, vol. ii., p. 331; vol. viii., p. 443, and vol. xviii., p. 453.

Orithyia luteola.

Orithyia luteola, *Blackw.*, *Ann. and Mag. of Nat. Hist.*, ser. 3, vol. xvi., p. 89.

Orithyia gnava.

Orithyia gnava (female), *Blackw.*, *Ann. and Mag. of Nat. Hist.*, ser. 3, vol. xvi., p. 90.

The male of this species, which seems to have escaped the observation of arachnologists, is not so robust as the female, but its legs are

r coloured, and the protuberance on
the anterior row are seated is more
ort; the radial is stronger than the
int is oval, pointed at its extremity.
concave within, comprising the palpal
loped, prominent, not very complex in
llow colour. The convex sides of the
ds each other.

THERIDIIDÆ.

HERIDION, *Walck.*

Plate 2, fig. 10.

of an inch; length of the cephalothorax,
he abdomen, $\frac{1}{12}$; length of an anterior
hird pair, $\frac{1}{8}$.

x, glossy, compressed before, rounded
has an indentation in the medial line of
s are conical and vertical; the maxillæ
e extremity, on the outer side, and in-
is semicircular; the sternum is heart-
d provided with hairs; the first pair is
l the fourth pair is the shortest; each
aws; the two superior ones are curved,
e inferior one is inflected near its base;
a curved minutely pectinated claw at
are of a pale-yellowish colour. The
ior part of the cephalothorax in two
rmediate ones form a square, the ante-
a small protuberance, being the largest
eyes of each lateral pair are placed on a
guous. The abdomen is oviform, convex
base of the cephalothorax; it is of a
der part being the palest, with an irre-
pots extending along each side of the
he sexual organs, which are moderately
with them a triangular process directed
wish-red colour.

and darker coloured than the female.
is stronger than the cubital joint; the
d hairy externally, concave within, com-
ch are well developed, rather complex
k, slightly-curved, pointed spine on the
l forwards. The convex sides of the
ards each other.

his species are darker coloured than adult

Theridion læve, n. sp.

Length of an immature female, $\frac{1}{12}$th of an inch; length of the cephalothorax, $\frac{1}{24}$; breadth, $\frac{1}{30}$; breadth of the abdomen, $\frac{1}{24}$; length of an anterior leg, $\frac{1}{8}$; length of a leg of the third pair, $\frac{1}{12}$.

The eyes are seated on black spots on the anterior part of the cephalothorax; the four intermediate ones form a square, the two anterior ones, which are placed on a small protuberance, being the largest of the eight; the eyes of each lateral pair are seated on a minute tubercle, and are near to each other, but not in contact. The cephalothorax is slightly compressed before, rounded in front, and on the sides convex, glossy, and has a slight indentation in the medial line of the posterior region; it is of a yellowish-white colour, a brown band extending from each lateral pair of eyes nearly to its base. The falces are conical, vertical, and have a brownish-yellow hue. The maxillæ are obliquely truncated at the extremity on the outer side, and inclined towards the lip, which is short and pointed at the apex. These organs have a pale-yellowish hue, the former being tinged with brown on the outer side. The sternum is heart-shaped, convex, glossy, and of a dull yellow colour, with brownish-black lateral margins. The legs are slender, supplied with short hairs, and are of a pale yellowish-brown hue, marked obscurely with soot-colour at the articulation of the joints; the first pair is the longest, then the second, and the third pair is the shortest. The palpi are short, without soot-coloured marks, and are terminated by a small curved claw. The abdomen is oviform, convex above, projects over the base of the cephalothorax, and is of a dull-yellowish colour, freckled with white; a pale brown dentated band extends from the anterior extremity of the upper part, along the middle, about two-thirds of its length, and is followed by three soot-coloured lines that meet at the coccyx, the intermediate one being composed of small spots; the spinners have a brownish-black hue, and the outer side of the branchial opercula is soot-coloured.

Genus Argyrodes, *Simon.*

Argyrodes rostrata, n. sp. Plate 2, fig. 11.

Length of the male, from the anterior part of the cephalothorax to the summit of the abdominal cone, $\frac{1}{12}$ of an inch; length of the cephalothorax, $\frac{1}{20}$; breadth, $\frac{1}{30}$; breadth of the abdomen, $\frac{1}{24}$; length of an anterior leg, $\frac{1}{4}$; length of a leg of the third pair, $\frac{1}{12}$.

The abdomen rises from its anterior extremity, which projects a little over the base of the cephalothorax, into a large obtuse cone greatly elevated above the spinners; the upper part has a brilliant silvery-white colour, with a brownish-black band extending along the middle to the summit of the abdominal cone; the sides, posterior face of the cone, and under part are of a brownish-black colour, the last having a tinge of red; a white point is projected from the upper part on each side; a line of the same hue, bifid at its superior extremity, extends along each side of the posterior face of the cone, and two small

ely, immediately before the spinners,
ts, streaks, and spots have a brilliant
rax is oval, moderately convex, glossy,
medial line of the posterior part, and
in the cephalic region, which has a
uely forwards and upwards, whose
ith hairs; it is of a red-brown colour,
e summit of the cone being much the
, vertical, and armed with a few teeth
llæ are somewhat enlarged at the ex-
owards the lip. These organs are of a
being rather the darker. The lip is
t the apex, and the sternum is heart-
hese parts have a brownish-black hue.
alic cone; the four intermediate ones
anterior ones, which are the largest of
summit of the cone, in front, and the
w the summit; the eyes of each lateral
bercle nearer to its base, and are con-
provided with short hairs, and have a
he first pair is the longest, then the
e shortest. The palpi resemble the legs
of the digital joint, which has a dark-
the cubital is larger than the radial
is oval, convex, and hairy externally,
the palpal organs, which are highly
re, prominent at the extremity on the
wn colour.

closely allied to *Argyrodes epeiræ*, Sim.,
out difficulty by the more projecting (or
aracteristic process in front of the upper
al form, colours, and markings the two
; and probably the economy of the Sey-
hat of *A. epeiræ*, since the spider (*Cyr-*
f.) in whose webs the latter is found
e Seychelles Islands.]

y EPEIRIDÆ.

Epeira, *Walck.*

peira nocturna, Vins.]

an inch; length of the cephalothorax, $\frac{1}{5}$;
domen, $\frac{1}{4}$. The first pair of legs is the
d the third pair is the shortest; but as

these limbs were mutilated, their absolute length could not be determined with accuracy.

The cephalothorax is compressed before, rounded in front and on the sides, convex, depressed at the base, with an indentation on the medial line of the posterior region; it is thinly clothed with short whitish hairs, and is of a reddish-yellow colour. The eyes are disposed on the anterior part of the cephalothorax in two transverse rows; the four intermediate ones are seated on a prominence, and nearly form a square, the two anterior ones, which are wider apart than the posterior ones, being the largest of the eight; the eyes of each lateral pair are placed obliquely on a tubercle, and are near to each other, but not in contact. The falces are powerful, conical, vertical, and armed with teeth on the inner surface; the maxillæ are short, straight, and enlarged and rounded at the extremity. These organs are of a dull-yellowish hue, tinged with soot-colour on the inner surface. The lip, which is semicircular, is of a reddish-brown colour at the base, that of the margin and apex being yellow. The sternum is heart-shaped, with small eminences on the sides, opposite to the legs; it has a brownish-yellow hue, the medial line being the palest. The legs are provided with hairs, and have a brownish-yellow hue, with reddish-brown annuli. The palpi resemble the legs in colour, and are terminated by a curved, pectinated claw. The abdomen is broad, triangular, somewhat depressed, and projects over the base of the cephalothorax; it is sparingly supplied with short white hairs, and has on the upper part a large, dentated, dark-brown mark, that tapers to the spinners; it is obscurely mottled with dull yellow, and is barred transversely with dark brown above the coccyx; the anterior part comprises a dark-brown band that extends more than a third of its length, and is triangular at its anterior, and obtuse at its posterior extremity; brown lines pass obliquely from the lateral margins of the dark-brown mark to the upper part of the sides, which, with the under part, are of a brownish-yellow hue, streaked and freckled with brown; the middle of the under part is brown, tinged with dull-yellow in the medial line, and has a pale-yellow line on each side, which is enlarged and curved inwards at its posterior extremity. The sexual organs are well developed, of a red-brown colour, and project from their anterior margin a pointed, prominent process, directed backwards, which is somewhat depressed and hollowed on the upper side at its extremity.

[This spider, *Epeira obscura*, is, without doubt, the *E. nocturna*, Vinson. (Aranéides des Iles de la Réunion, &c., Pl. 4, fig. 3).]

Epeira Morelii.

Epeira Morelii, *Vinson, Aranéides des Iles de la Réunion, Maurice et Madagascar*, p. 166, Pl. iv., fig. iv.

Length of the female, $\frac{5}{12}$ of an inch; length of the cephalothorax, $\frac{1}{6}$; breadth, $\frac{1}{12}$; breadth of the abdomen, $\frac{1}{4}$; length of an anterior leg, $\frac{1}{2}$; length of a leg of the third pair, $\frac{1}{4}$.

white spots are placed transversely, immediately before the spinners, on the under side; these points, streaks, and spots have a brilliant silvery lustre. The cephalothorax is oval, moderately convex, glossy, with a slight indentation in the medial line of the posterior part, and a pointed conical prominence in the cephalic region, which has a process in front directed obliquely forwards and upwards, whose obtuse extremity is provided with hairs; it is of a red-brown colour, the fine lateral margins and the summit of the cone being much the darkest. The falces are conical, vertical, and armed with a few teeth on the inner surface; the maxillæ are somewhat enlarged at the extremity, and slightly inclined towards the lip. These organs are of a red-brown colour, the maxillæ being rather the darker. The lip is semicircular, and prominent at the apex, and the sternum is heart-shaped, convex, and glossy. These parts have a brownish-black hue. The eyes are seated on the cephalic cone; the four intermediate ones nearly form a square; the two anterior ones, which are the largest of the eight, are situated on the summit of the cone, in front, and the two posterior ones a little below the summit; the eyes of each lateral pair are placed on a minute tubercle nearer to its base, and are contiguous. The legs are slender, provided with short hairs, and have a pale yellowish-brown hue; the first pair is the longest, then the second, and the third pair is the shortest. The palpi resemble the legs in colour, with the exception of the digital joint, which has a dark-brown hue, tinged with red; the cubital is larger than the radial joint, and the digital joint is oval, convex, and hairy externally, concave within, compressing the palpal organs, which are highly developed, complex in structure, prominent at the extremity on the outer side, and are of a red-brown colour.

[This spider is exceedingly closely allied to *Argyrodes epeiræ*, Sim., but may be distinguished without difficulty by the more projecting (or less vertical) direction of the characteristic process in front of the upper part of the caput. In general form, colours, and markings the two species are remarkably similar; and probably the economy of the Seychelles species is the same as that of *A. epeiræ*, since the spider (*Cyrtophora* (*Epeira*) *opuntiæ*, Duf.) in whose webs the latter is found appears to be also found in the Seychelles Islands.]

Family EPEIRIDÆ.

Genus EPEIRA, *Walck.*

EPEIRA OBSCURA, n. sp. [Epeira nocturna, Vins.]

Length of the female, [illegible] of an inch; length of the cephalothorax, [illegible]; breadth, [illegible]; breadth of the [illegible]. The first pair of legs is the longest, then [illegible] rd pair is the shortest; but as-

under part has a dull reddish-brown hue, obscurely spotted with yellowish-white, that of the branchial opercula being brown. The sexual organs are highly developed, very prominent, much enlarged at the extremity, which has a convexity on each side,[1] and their colour is dark red-brown. The cephalothorax is somewhat oval, slightly compressed before, moderately rounded on the sides, convex, glossy, with a large transverse indentation in the medial line, and is of a dark red-brown colour, the medial region being the palest. The falces are conical, rather prominent, and armed with a few teeth on the inner surface: the maxillæ are obliquely truncated at the extremity, on the outer side, and slightly inclined towards the lip, which is semicircular, but somewhat pointed at the apex; and the sternum is oblong heart-shaped, with small eminences on the sides, opposite to the legs. These parts have a yellowish-brown colour, the falces being the darkest. The eyes are disposed on the anterior part of the cephalothorax in two transverse rows, high above the frontal margin; the four intermediate ones form a square, the anterior ones, which are seated on a small prominence, being the largest and darkest coloured of the eight; the eyes of each lateral pair are seated on a minute tubercle, and are contiguous. The legs are long, slender, provided with a few hairs, and are of a yellowish-brown hue, with red-brown annuli; the first pair is the longest, then the second, and the third pair is the shortest; each tarsus is terminated by claws of the usual number and structure. The palpi are short, of a yellowish-white colour, with the exception of the radial and digital joints, which have a dark-brown hue, and the latter has a slender, curved claw at its extremity.

The male is smaller and darker coloured than the female, but its legs are longer, an anterior one measuring $\frac{3}{12}$ of an inch; the large conical protuberance is more erect, the annuli on the legs are scarcely perceptible, except at the joints, and in the space surrounded by the eyes there is a cone directed obliquely forwards, which is surmounted by a few hairs. The design formed on the abdomen by the distribution of its colours is similar in both sexes. The humeral, radial, and digital joints of the palpi are of a dark-brown colour, tinged with red, and that of the cubital joint is yellowish-brown; the radial joint is produced at its extremity, on the outer side; the digital joint is oval, convex, and hairy externally, concave within, comprising the palpal organs, which are well developed, complex in structure, and of a red-brown colour. The convex side of the digital joints are directed towards each other.

[This spider is undoubtedly an Argyrodes, and very closely allied to *A. Syriaca* (Camb.),[2] which it resembles in the very characteristic

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[1] That on the left side of the specimen described appeared to be abnormal in form.

[2] Spiders of Palestine and Syria, "Proceedings Zoological Society," 1872, p. 279, pl. xiii., fig. 10.

ex of the caput in the male; the larger and a considerable difference in the form h other distinctions of colours, markings, ke the male easily distinguishable, while pment of the epigyne of the female is emale of *E. Syriaca*. The abnormal de- his sexual appendage, mentioned in Mr. pparent, being evidently caused by the ll particle of resinous matter, the colour mble nearly that of the appendage in

s NEPHILA, *Leach.*

kenaer, Hist. Nat. des Insect. Apt., tom.

te 2, fig. 13.

, *Die Arachn.*, bd. vi., p. 138, tab. 213, *Nat. des Insect. Apt.*, tom. ii., p. 99.

an inch; length of the cephalothorax, $\frac{3}{10}$; bdomen, $\frac{1}{15}$; length of an anterior leg, $\frac{5}{8}$; pair, $\frac{1}{4}$.

black spots on the anterior part of the ermediate ones nearly form a square, the her wider apart than the posterior ones, otuberance, being the largest of the eight; are seated on a tubercle, and are near to et. The cephalothorax is convex, glossy, in front and on the sides, with a broad ne of the posterior region; it is of a dull- n patch on each side of the thorax. The rmed with one or two small teeth on the lull-yellow colour. The maxillæ are en- extremity, and slightly inclined towards r. These parts are of a brownish-yellow lark-brown hue on each side of its base. ed, with small eminences on the sides, of a dark-brown colour, a yellowish-white remity, extending along the middle. The ded with hairs and some long spines, and lour; the first pair is the longest, then the the shortest. The palpi are short, and of he digital joint being brown; the radial is bital joint, and the digital joint is oval, ly, concave within, comprising the palpal

organs, which are highly developed, sub-globose, glossy, with a long, slender, moderately curved process at their extremity, whose pointed termination is slightly recurved, and are of a dark-brown colour. The abdomen is subcylindrical, rather broader at the anterior than at the posterior extremity, which is rounded, and projects a little beyond the spinners; a broad, irregular, olive-brown band extends along the middle of the upper part, and comprises some pale-yellow spots, six, which are minute, being disposed in pairs immediately above the spinners; a pale-yellow band curves round the anterior extremity, and passes, with some interruptions, along each side of the medial band; the sides are of an olive-brown colour, marked with irregular spots and streaks of a yellow hue, and a brown olive-brown band, bounded laterally by a white line, extends along the middle of the under part; the colour of the branchial opercula is dark-brown.

It will be perceived that I have felt some hesitation in announcing this Nephila, which seems to be unknown to arachnologists, as the male of *N. plumipes*, to which it appears to approximate more nearly than to any other species that I am acquainted with.

[I have carefully compared the example from which Mr. Blackwall's description is made with several undoubted examples of the male of *N. plumipes* received from the Brazils, and can find no specific difference whatever. This sex is described and figured (the figure is very imperfect) by Dr. B. S. Wilder, in the "Proceedings of the Boston Society of Natural History" for October, 1865.]

Genus Tetragnatha, *Latr.*

Tetragnatha minax, n. sp. Plate 2, fig. 14.

Length of the male (not including the falces), $\frac{7}{12}$ of an inch; length of a falx, $\frac{1}{6}$; length of the cephalothorax, $\frac{1}{5}$; breadth, $\frac{1}{12}$; breadth of the abdomen, $\frac{1}{12}$; length of an anterior leg, $1\frac{1}{4}$; length of a leg of the third pair, $\frac{3}{4}$.

The eyes are seated on black spots, and are disposed on the anterior part of the cephalothorax in two transverse, nearly parallel rows; the four intermediate ones describe a square, the anterior ones, which are placed on a small protuberance, being the largest, and the anterior eye of each lateral pair the smallest of the eight. The cephalothorax is long, moderately convex, glossy, compressed before, rounded in front, slightly so on the sides, has an indentation in the medial line of the posterior region, and is sparingly supplied with short pale hairs; the falces are very long and prominent, widely divergent, narrower at the base than at the extremity, and armed with a long, slightly curved, reddish-brown fang, a curved, pointed process directed forwards near the extremity of the upper part, towards the inner side, and a row of teeth on each side of the groove occupied by the fang when in a state of repose; the superior row comprises twelve teeth, the anterior one being the largest, and the

conical prominence at the apex of the caput in the male; the larger size, however, of the spider, and a considerable difference in the form of the abdomen, together with other distinctions of colours, markings, and palpal structure will make the male easily distinguishable, while the very remarkable development of the epigyne of the female is totally unlike that of the female of *E. Syriaca*. The abnormal development of one side of this sexual appendage, mentioned in Mr. Blackwall's note, is only apparent, being evidently caused by the accidental adhesion of a small particle of resinous matter, the colour of which happens to resemble nearly that of the appendage in question.]

Genus NEPHILA, *Leach.*

NEPHILA INAURATA.

Nephila inaurata, *Walckenaer, Hist. Nat. des Insect. Apt.*, tom. ii., p. 94.

NEPHILA PLUMIPES. Plate 2, fig. 13.

Nephila plumipes, *Koch, Die Arachn.*, bd. vi., p. 138, tab. 213, fig. 529. *Walckenaer, Hist. Nat. des Insect. Apt.*, tom. ii., p. 99.

Length of the male, $\frac{7}{32}$ of an inch; length of the cephalothorax, $\frac{1}{10}$; breadth, $\frac{1}{12}$: breadth of the abdomen, $\frac{1}{15}$; length of an anterior leg, $\frac{4}{5}$; length of a leg of the third pair, $\frac{1}{4}$.

The eyes are seated on black spots on the anterior part of the cephalothorax; the four intermediate ones nearly form a square, the anterior ones, which are rather wider apart than the posterior ones, and are placed on a small protuberance, being the largest of the eight; the eyes of each lateral pair are seated on a tubercle, and are near to each other, but not in contact. The cephalothorax is convex, glossy, compressed before, rounded in front and on the sides, with a broad indentation in the medial line of the posterior region; it is of a dull-yellow colour, with a brown patch on each side of the thorax. The falces are conical, vertical, armed with one or two small teeth on the inner surface, and are of a dull-yellow colour. The maxillæ are enlarged and rounded at the extremity, and slightly inclined towards the lip, which is triangular. These parts are of a brownish-yellow colour, the latter having a dark-brown hue on each side of its base. The sternum is heart-shaped, with small eminences on the sides, opposite to the legs, and is of a dark-brown colour, a yellowish-white line, which tapers to its extremity, extending along the middle. The legs are long, slender, provided with hairs and some long spines, and are of a brownish-yellow colour; the first pair is the longest, then the second, and the third pair is the shortest. The palpi are short, and of a pale-yellow hue, that of the digital joint being brown; the radial is slightly larger than the cubital joint, and the digital joint is oval, convex, and hairy externally, concave within, comprising the palpal

rounded in front and on the sides, convex, glossy, with a large indentation in the medial line of the posterior region, and is of a brownish-yellow colour. The eyes are seated on black spots, and are disposed in two transverse rows on the anterior part of the cephalothorax; the four intermediate ones form a square; the two anterior ones, which are rather the largest of the eight, and seated on a slight protuberance, being situated immediately above the frontal margin; the eyes of each lateral pair are placed obliquely on a small tubercle, and are contiguous. The falces are powerful, very convex in front, vertical, and armed with teeth on the inner surface; the maxillæ are straight, and increase in breadth from the base to the extremity, which is angular and prominent on the outer side. These parts have a brownish-yellow hue, the latter being the darker, particularly on the inner side. The lip is semicircular, and of a red-brown colour, the apex being rather the palest; and the sternum is heart-shaped, with prominences on the sides, opposite to the legs, and has a yellowish-brown hue. The legs are long, slender, provided with hairs and a few fine spines, and are of a dark-brown colour, with the exception of the coxæ, femora, and genual joints, which have a yellowish-brown hue; the first pair is the longest, then the second, and the third pair is the shortest; each tarsus is terminated by claws of the usual number and structure. The palpi, which are slender, resemble the legs in colour, and have a slightly curved, minutely pectinated claw at their extremity.

With the Tetragnatha described above, which belongs to the family Coadunatæ of Walckenaer, I have associated the name of Professor T. Thorell, Ph. D., whose important works on arachnology should be carefully perused by all students of that department of zoology.

[This species is exceedingly closely allied to *Meta decorata* (India), and more nearly still to *M. quinquelineata*, Keys. (Bogota, South America); it is also nearly allied to *M. argentata*, Camb., and *M. culta*, Camb., Ceylon. All these species have been described as belonging to the genus Tetragnatha.]

inferior row consists of about sixteen teeth. The lip is semicircular and prominent at the apex; the maxillæ are long, straight, and enlarged at the extremity, which is rounded on the inner side, and angular and prominent on the outer side; the sternum is heart-shaped, with small eminences on the sides, opposite to the legs; the legs are very long, slender, and provided with hairs and spines; the first pair is the longest, then the second, and the third pair is much the shortest; each tarsus is terminated by claws of the usual number and structure. These parts are of a pale, dull-yellow colour; the inner margin of the maxillæ is soot-coloured, and the base of the lip has a red-brown hue. The palpi are long, slender, and of a yellowish-white colour; the radial is longer than the cubital joint and clavate; the digital joint consists of two narrow, membraneous parts clothed with hairs externally, one of which is much longer than the other; with the base of these parts the palpal organs are connected; they are moderately developed, glossy, sub-globose, and terminate in a prominent, curved spine, enveloped in membrane, which is recurved and somewhat enlarged at its extremity, and they are of a pale red-brown colour. The abdomen is long, subcylindrical, and tapers to its extremity, which projects a little beyond the spinners; it is of a dull-yellowish colour reticulated with brown lines; a ramified brown line extends along the middle of the upper part, and a longitudinal band of the same hue, freckled with minute yellowish-white spots, and bounded laterally by lines composed of numerous similar spots, occurs in the middle of the under part; the branchial opercula have a yellowish-brown hue, and there are a few white spots about the base of the spinners.

The immature female is rather darker coloured than the adult male.

TETRAGNATHA THORELLII, n. sp. [Meta, Koch]. Plate 2, fig. 15.

Length of the female, $\frac{1}{4}$th of an inch; length of the cephalothorax, $\frac{1}{10}$; breadth, $\frac{1}{12}$; breadth of the abdomen, $\frac{1}{10}$; length of an anterior leg, $\frac{2}{3}$; length of a leg of the third pair, $\frac{1}{4}$.

The abdomen is robust, subcylindrical, projects a little over the base of the cephalothorax, and curves abruptly downwards at its posterior extremity; the upper part and the superior region of the sides are of a bright silvery-white colour reticulated with fine brown lines, the latter having a slight golden tinge; a pale-brown ramified band extends along the middle of the former to the commencement of the posterior curve, and on each side of the curve there is a series of black spots that diminish in size as they approach the spinners; a broad brown band, palest in the medial line, whose upper margin is irregular, occupies the inferior region of the sides; the under part has a longitudinal brown band in the middle, comprising a dull-yellowish line, and is bounded laterally by a pale-brown line spotted with minute silvery spots; the branchial opercula have a brownish-yellow colour, and that of the sexual organs, which are moderately developed, is dark reddish-brown. The cephalothorax is compressed before,

t. 9 (skull). F. jubata, *Schreb.* F. venatica, *A. Smith.* F. fearonis (?), *A. Smith.* Cynælurus sœmmeringii, *Rüppell.*

Professor Owen,[3] however, places it in the genus Felis. He says, "The os hyoides is connected to the cranium by an uninterrupted series of bones, thus connecting it with the cats. It possesses the circular pupil common to lion, tiger, leopard, and jaguar.

"In the form of the œsophagus and in the transverse rugæ of its lower half the Cheetah agrees with the lion, and in it, as in the other Feles, the œsophagus is not prolonged into the abdomen, but terminates, immediately after passing through the diaphragm, in the stomach; this organ in the Cheetah has all the peculiarities which are found in the genus Felis. The intestines also agree in character with those of that group; and the cæcum, as usual in it, is simple, having none of the convolution which is found in the dog. The liver, pancreas and spleen resemble those of the cats generally; as do also the kidneys in the arborescent form of their superficial veins—a form, however, equally common to the Viverridæ and the Felidæ, which also agree in having spiculæ on the tongue.

"The thoracic viscera of the Cheetah agree with those of the cats. The lytta or rudiment of the lingual bone, so conspicuous in the dog, is reduced in it, as in the other feline animals, to a small vestige.

"There is, as in the Feles generally, no bone of the penis; and the glans, as usual in them, has retroverted papillæ.

"The elastic ligaments of the ungual phalanges exist in the same number and position as those of the lion; they are, however, longer and more slender, their length alone occasioning the incomplete retraction of the claws, as compared with the rest of the Felidæ."

Professor Owen concludes by observing that in the circulatory, respiratory, digestive, and generative systems, the Cheetah conforms to the typical structure of the genus Felis.

Habitat: Africa, Asia, Persia.[4] From Southern and Western India, through Persia, Syria, Northern and Central Africa, to the Cape of Good Hope.[5]

Dr. Kirk[6] mentions it as occurring in the Makalalo country (not common) in his list of the Mammals of Zambesia.

The dissection was commenced towards the latter end of October. On taking off the skin, the panniculus carnosus was found to be moderately well developed in the fore part of the body, but more fully in the hinder part.

The trapezius was divided as usual into the clavicularis (corresponding to the anomalous cleido-occipital in man), and scapulares, superior and inferior.

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[3] On the Anatomy of the Cheetah, Felis Jubata, Schreb. "Proceedings of the Zoological Society of London," part i., 1833, p. 108.

[4] Gray, *loc. cit.*

[5] Wallace, "Geographical Distribution of Animals," vol. ii. p. 193.

[6] "Proceedings Zoological Society of London," 1864, p. 653.

II.—Myology of the Cheetah, or Hunting Leopard of India (Felis Jubata). By F. Ogilby Ross, Student in Medicine, of Trinity College, Dublin.

[Read, November 30, 1876.]

The following facts, relative to the myology of the Cheetah, are founded on the examination of a specimen which Professors Macalister and Haughton kindly allowed me to dissect.

The animal, a fine male, was presented by Viscount Southwell to the Zoological Gardens, where it lived in good health since 1872.

A little more than a month ago it died in convulsions, for which no cause was discovered on *post-mortem* examination.

Before proceeding to describe its myology, a few facts relative to its history and general anatomy may not be out of place.

There are found in India two animals with spotted skins—the common panther of naturalists, and another, the hunting leopard, named after Daubenton, the Guepard (the hunting leopard), known to the ancients.

The Arabians also knew of and distinguished two animals with spotted skins, the first under the name of Nemer, the other under that of Fehd; the latter Bocchart considered identical with the lynx, Cuvier with the hunting leopard. Aristotle says its young were born blind. According to Herodotus, it inhabited Africa with the ibis. Its skin was spotted, and its natural disposition tameable, according to Eustathius.

The last two traits seem inapplicable to any but the animal called Fehd by the Arabians. Their not referring to its being used for hunting purposes is very natural, if, as Eldemiri informs us, the first person who so employed it was Chalib, the son of Wail.[1]

Dr. J. E. Gray[2] places the hunting leopards in a separate tribe, that of the Guepardina, of which the following are the chief characteristics: Head short, subglobate; face very short; neck slightly maned; legs elongate, slender, subequal; tail elongate; ears rounded; pupil round (?). Skull: face very short, convex; the processes of the frontals and intermaxillæ very short, not separating the nasals from the maxillæ; the flesh tooth of the upper jaw has no lobe, only a very slightly raised, scarcely visible keeled ridge, and is thin and compressed; the front, upper false grinder, distinct, small; orbits incomplete, moderate.

Genus, Guepardа, *Gray*. Cynælurus, *Wagner*.

Guepardа guttata.

Felis guttata, *Herm.; Blainv., Ostéographie*, Felis: t. 4, (skeleton);

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[1] Cuvier, "Animal Kingdom," by Griffiths, Mammalia, vol. ii., p. 460.

[2] Dr. J. E. Gray's Notes on the Skulls of Cats, "Proceedings of the Zoological Society of London," 1867.

lower ribs: beneath it was a large bursa and also a mass of firm white fat, weighing about 2 oz. The tendon of insertion was scarcely at all twisted on itself, as in man: insertion as usual.

The triceps accessorius (·05), triangular in shape, about one inch broad and long, and very thin, was inserted by a long fine tendon into the inner and posterior surface of the olecranon. Supplied by the musculo-spiral nerve.

Subscapularis (4·90), very thick. Pectoralis minor absent.

Pectoralis major (16·86) consisted of two layers, embracing between their insertions the triceps. The superficial layer arose from the median line of the thorax; closely connected with the opposite muscle. Insertion into a ridge on the outer surface of the humerus for about eight inches; also into the greater tuberosity, continuous below with the clavicular portion of the deltoid.

The deep, the smaller of the two, arose from the sternum, nearer its lateral margin, and was inserted into the lesser tuberosity, and a line leading downwards and forwards from it for about three inches.

Coraco-brachialis major, and subclavius, were absent.

The coraco-brachialis minor (·06) arose by a fine tendon from the upper border of the glenoid cavity. It soon became fleshy, and was inserted tendinous and fleshy, immediately below the facet for the subscapularis tendon, which it crossed over, on the lesser tuberosity. The above was symmetrical.

The deltoid, as usual, divisible into three portions—scapularis, acromialis, and clavicularis, though the division was more or less artificial in some places.

Scapularis, from spine of scapula to crest on humerus, = 1·60.

Acromialis (1·00), from acromion process, and where it should have arisen from the clavicle, was more or less fused with the clavicularis (1·85), which also arose from the acromion. The two latter became continuous with the triceps, about an inch from its insertion, there being no traceable connexion with the radius. A floating clavicle was developed in the substance of the clavicularis.

Supra- and infra-spinati as usual; tendon of insertion of former was fibro-cartilaginous. Respective weights 7·36 and 5·65.

Serratus magnus arose from upper ten ribs and formed one mass, not divisible into the three usual portions. Insertion was normal, but rather larger than usual, = 8·62.

The spino-glenoid ligament consisted of two layers with fat between, attached posteriorly to the under surface of the acromion, internally and posteriorly to base of acromion, and anteriorly to the edge of the glenoid cavity, forming an arch corresponding to the neck of the scapula, beneath which passed the supra-scapular nerve.

The biceps humeri (3·80) had only one head of origin from the scapula, immediately above the glenoid cavity, which pierced the capsular ligament, and united, at its insertion into the radius, with part of the tendon of the brachiæus.

The brachiæus (·62) arose from the greater part of the anterior

scapula. Just previous to its insertion it fused with the tra- acromialis, or omo-atlanticus of Professor Haughton. Weight together = 2·65.

e scapularis inferior, smaller and thinner than the preceding, from the upper six dorsal spines, and had also an additional slip gin from the latissimus dorsi of the opposite side, inserted into sterior fifth of the lower border of the spine of the scapula. ht = 1·40.

e cleido-mastoid arose from the mastoid process, and was in- into the tendinous clavicular line at the junction of the clavi- trapezius and clavicular deltoid. Weight = ·70.

e trachelo-acromialis, or omo-atlanticus of Professor Haughton, from the transverse process of the atlas, was inserted into the or scapular portion of the trapezius.

e rhomboideus divided into three portions, major, minor, and tal, the two latter being fused together.

e occipital arose as usual from the occiput, and soon fused with inor, which took its origin from an aponeurosis, connected with rst six cervical spines, and also directly from the 7th cervical st dorsal spines. It was inserted into the greater part of the ior border of the scapula = 2·75. The major, much smaller, from the 2nd, 3rd, and 4th dorsal spines. Insertion into the r angle of the scapula, connected with the origin of teres major. ht = ·90.

th major and minor were very coarsely fibred, flabby, and, ally the former, mixed with a large quantity of firm yellowish mounting almost to fatty degeneration.

e major was also more or less united with the serratus magnus, rous fibres and masses of fat extending from one to the other.

e teres major (3·35) had an extensive origin from the internal e of the scapula, posterior portion, and also from the aponeu- covering the subscapularis. Insertion fleshy, about an inch , into the upper part of the internal surface of the humerus, intimately connected with the internal head of the triceps.

musculo-spiral nerve.

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and inner surface of the humerus. The tendon of insertion was broad, and split into three parts.

The major was inserted into the anterior surface of the ulna, immediately underneath the origin of flexor profundus; the middle, small and round, into the anterior surface; and the smallest, united with the biceps tendon.

The triceps arose as usual by three heads, one scapular, and two humeral; between them the musculo-spiral nerve. Origin and insertion normal, the relation of the three heads was: longus, 10·50; externus, 4·26; internus, ·60.

Anconeus internus, or epitrochleo-anconeus (Gruber) (·05), was very distinct; it arose from the inner condyle, crossed over the ulnar nerve, and was inserted into the olecranon process. It was about an inch in length. The externus was absent.

The pronator radii teres (·35), normal. From the tendon of insertion, which was prolonged to within two inches of the end of the radius, a fine tendon was given off, which united with the palmar fascia.

The flexor carpi radialis (·20), thin, fleshy belly; inserted into second metacarpal, giving off slips to the styloid process of radius, and the trapezium, as it passed through the groove. The membrane completing the groove was very tough and strong.

The palmaris longus (·75), very large, took the ordinary course of the flexor sublimis, which was quite rudimentary, weighing only (·01). The latter arose from the front of the tendon of the flexor profundus, dividing into three tendons, and also giving off a slip to the flexor profundus. The three tendons went to the three middle digits of the manus, each of the three middle digits having thus two tendons, one from the palmaris longus, and one from the flexor sublimis. The fourth had only one, viz., from the palmaris longus. Opposite the metacarpophalangeal articulation the tendons united, sending off a process on each side. Insertion as usual.

Flexor carpi ulnaris (·70) arose by two heads, separated by the ulnar nerve.

Flexor digitorum profundus (2·06) and flexor longus pollicis (·15), which were intimately connected at their insertion, arose from radius, ulna, and interosseous membrane. The five tendons were united at the wrist, and passed to the five digits, being inserted into the last phalanges. The flexor sublimis arose from the front of the united tendons before they passed under the annular ligament, which was very strong.

The pronator quadratus (·16) extended up as far as the oblique ligament, which was placed lower than usual, about 1½ inches below the tubercle of the radius.

The supinator radii longus and extensor carpi radialis brevior were both absent.

Extensor carpi radialis longior (·80), extensor carpi ulnaris (·28), and extensor ossis metacarpi pollicis (·12) had all normal origins and insertions.

Supinator radii brevis (·10), besides its usual radial insertion, had a

good many muscular fibres attached to the upper part of the interosseous membrane.

Extensor longus digitorum (·40) divided underneath annular ligament into four very thin weak tendons.

The extensor minimi digiti (auricularis) (·10) was inserted into the base of the second phalanx of the fifth digit. Extensor minimi digiti tertii (·05) arose from upper fifth of radius and external lateral ligament, ran alongside the auricularis, passing through a separate compartment of the annular ligament, and was inserted into the outer surface of the base of first phalanx of fifth digit.

Extensor carpi ulnaris (·28) arose from upper third of posterior border of ulna. Extensor indicis et pollicis (·05), made up of the extensor secundi internodii pollicis, and indicator, presented a rather remarkable arrangement. It arose fleshy by two heads—one from the external surface of ulna, one inch below olecranon, the other from the radius, above the superior radio-ulnar ligament; it then passed downwards, and, on the dorsum of the manus, crossed beneath the tendons of the extensor longus digitorum, and was inserted into the base of the claw of pollux. The above arrangement was symmetrical.

Adductor minimi digiti (·08).

There were four palmar interossei, weighing respectively ·06; ·05; ·02; ·01; the fourth corresponding to the interosseus of Henle in man. It arose from the deep palmar fascia, and was inserted into the dorsal aponeurosis of thumb.

The four dorsal interossei weighed respectively ·10; ·05; ·10; ·05.

The first palmar and first dorsal interossei were inserted in a peculiar manner, and the arrangement occurred on both sides. Attached to the posterior end of the base of each claw were two elastic bands—one on each side—which extended to a tubercle on the head of the phalanx. Into these bands the tendons of the first dorsal and palmar interossei were attached, about the middle, seemingly acting as retractors of the claw.

The palmar interossei being removed, a ligament was seen extending from the carpus to the fourth metacarpal bone. It was attached to the carpus by three slips: the middle one continuous with the external retinaculum of the pisiform; the internal one attached to the head of the fifth metacarpal; and the external, to the unciform and os magnum. Its other end was inserted into the fourth metacarpal, about its centre. Opposite the carpo-metacarpal articulation, and for a short distance down the fourth metacarpal, it was free, not attached to the bone; but I could discover no structure passing underneath it.

It was similar in every respect to a corresponding one in the pes.

The same arrangement occurred in the other manus.

The sartorius (5·21), broad and thin, covering the greater portion of the inside of the thigh, arose from the iliac spine and part of Poupart's ligament. Insertion into the lower surface of head of tibia.

Psoas parvus and magnus and the iliacus (10·00); the two former arose together normally, after keeping together for about five inches

they separated; the parvus, being inserted by a very broad tendon into the magnus, joined with the iliacus, to be inserted into the lesser trochanter of the femur.

Pectineus (·35), inserted into femur above and anterior to lesser trochanter. The adductores primus, secundus, α and β, and tertius (17·5), were inseparably connected.

The quadratus femoris (·55), large and strong, arose from the external surface of the tuber ischii, and was inserted below the posterior extremity of the oblique line on the great trochanter. Obduratores externus (1·60) and internus (·83) were well marked and normal, the gemelli being closely connected with the latter. The tendon of the internus exhibited a beautiful arrangement; there were five primary tendons, each of which split into two, and some of these again subdivided.

The agitator caudæ (2·40) arose broad and fleshy from the upper part of the ilium immediately behind the acetabulum, and from the two anterior caudal vertebræ, lying alongside of and slightly overlapping vastus externus. After about eight inches it ended in a long and fine tendon, which passed beneath the vastus externus tendon, to be inserted, together with the rectus, into the anterior margin of patella.

Gluteus maximus (1·5), very small, was easily separable from the tensor vaginæ femoris; quadrilateral in shape. It arose from the posterior border of the ilium, and was inserted tendinous into the outer part of femur, below the great trochanter.

The medius (5·72) and minimus (·50), quite separate, were normal. The quartus (·40), really an easily separable anterior portion of the minimus.

Quintus (·12) was also present, and symmetrical; it arose immediately in front of the acetabulum, and running downwards and backwards was inserted into the commencement of the oblique line on the great trochanter.

Pyriformis (·65), normal.

The tensor vaginæ femoris (3·90) (gluteus minimus of Cuvier) arose from the anterior fourth of the crest of the ilium, and was inserted by means of the ilio-tibial ligament, which was very strongly marked, into the outer and back part of the tibia.

The biceps femoris (10·03), the long head arising from the tuber ischii, was spread out in a thin layer over the greater portion of the outer surface of the thigh, partly overlapping the adductors. The femoral head arose from the junction of upper and middle thirds of posterior surface of femur; it soon joined with the long head, to be inserted into the head of the fibula.

Bicipiti accessorius, absent.

Semimembranosus (13·30) and semitendinosus (4·70) arose by a common tendon from tuber ischii. Insertion as usual.

The gracilis (5·00). Very broad thin layer spread over the posterior fold of the thigh, arising from greater part of symphysis pubis, and inserted by a very weak narrow tendon into upper part of tibia.

Rectus (4·60). The usual origin, by two heads, and insertion. Vastus externus (8·00) and vastus internus (4·67), normal.

The crureus (3·35), almost inseparably connected with the vastus externus; in some places there was no natural division.

The popliteus (·65): sesamoid bone developed in tendon of origin; the muscle, almost quadrilateral in form, occupied the upper third of tibia.

The gastrocnemius externus and soleus, (3·67) and internus (1·87) had both a sesamoid bone developed in their tendons of origin. The soleus was inseparably connected with the former.

Plantaris (·02) arose from the outer condyle. It was inserted along with the gastrocnemius.

Flexor longus digitorum and flexor hallucis longus (together = 2·07) were united in their whole extent. They sent tendons to the five digits of the pes.

The tendon only of the tibialis posticus was present, the muscular part was wanting; the tendon extended from immediately above the internal malleolus to the tuberosity of the scaphoid.

Flexor brevis digitorum: scarcely any distinguishable muscular fibres about (·05).

Accessorius flexori longo was absent.

The tibialis anticus (1·30) arose from the upper part of the outer surface of the tibia, external tuberosity and corresponding part of interosseous membrane. There were very weak intermuscular septa. Insertion as usual into the first metatarsal bone.

The extensor hallucis was inseparably connected with the extensor longus digitorum (1·50), at least as far as their muscular bellies were concerned, the tendons being quite distinct; insertion normal.

Peroneus quinti (·11), brevis (·02), and longus (·40), as usual.

Extensor brevis digitorum (·12) was as usual.

The muscles of the pes presented no features of interest. The dorsal and plantar interossei exhibited a curious relation to one another, the weights of the plantar being ·07; ·07; ·06—the dorsal being ·07; ·08; ·07; ·07. On clearing off the muscles, a rather remarkable ligament, which I believe has not hitherto been noticed, was brought into view. It was about four inches long, rounded, white, and shining, attached at one end to the middle and external cuneiform bones, covering nearly the whole of their under surfaces, and at the other to the posterior half of the fourth metatarsal bone, covering its lower surface and part of its sides opposite the tarso-metatarsal articulation; and for about the posterior quarter inch of the second metatarsal bone it was free, smooth and round. I could discover no trace of a nerve or artery passing between it and the bone; it was symmetrical. An analogous one was present in the manus.

the Fore Limb.

	Avoirdupois Ounces.
·is, ...	1·20
ı superior, and trachelo-	
ılis, ...	2·65
s inferior, ...	1·40
. . . . .	—
. . . . .	0·70
. . . . .	0·90
ınd occipital, . . .	2·75
. . . . .	3·35
. . . . .	0·31
. . . . .	12·36
. . . . .	4·90
. . . . .	16·86
. . . . .	0·60
. . . . .	1·60
. . . . .	1·00
. . . . .	1·85
. . . . .	7·36
. . . . .	5·65
. . . . .	8·62
ris), ...	3·80
. . . . .	0·62
. . . . .	10·50
. . . . .	0·60
. . . . .	4·26
. . . . .	0·05
. . . .	0·05
. . . . .	0·35
. . . . .	0·20
. . . . .	0·75
. . . . .	0·70
mis, ...	0·01
ındus, ...	2·06
. . . . .	0·15
. . . . .	0·16
longior, . . .	0·80
. . . . .	0·10
ıgus, ...	0·40
. . . . .	0·10
. . . . .	0·05
, ...	0·28
pi pollicis, . . .	0·12
licis, ...	0·05
i, ...	0·08

crossei, 0·06, 0·05, 0·02, 0·01.
rossei, 0·10, 0·05, 0·10, 0·05.

Muscles of the Hind Limb.

	Avoirdupois Ounces.
1. Sartorius,	5·21
2. Psoas parvus,	2·35
3. Psoas magnus, } 4. Iliacus, }	10·00
5. Pectineus,	0·35
6. Adductor primus, } 7. Adductor secundus, α, } 8. Adductor secundus, β, } 9. Adductor tertius, }	17·50
10. Quadratus femoris,	0·55
11. Obdurator externus,	1·60
12. Obdurator internus,	0·83
13. Agitator caudæ,	2·40
14. Pyriformis,	0·65
15. Gluteus maximus,	1·50
16. Gluteus medius,	5·72
17. Gluteus minimus,	0·50
18. Gluteus quartus,	0·40
19. Gluteus quintus,	0·12
20. Tensor vaginæ femoris,	3·90
21. Biceps femoris,	10·03
22. Semimembranosus,	13·30
23. Semitendinosus,	4·70
24. Gracilis,	5·00
25. Rectus femoris,	4·60
26. Vastus externus,	8·00
27. Vastus internus,	4·67
28. Crureus,	3·35
29. Popliteus,	0·65
30. Gastrocnemius externus, } 31. Soleus, }	3·67
32. Gastrocnemius internus,	1·87
33. Plantaris,	0·02
34. Flexor longus digitorum, } 35. Flexor longus hallucis, }	2·07
36. Flexor digitorum brevis,	0·05
37. Tibialis anticus,	1·30
38. Extensor hallucis, } 39. Extensor digitorum longus, }	1·50
40. Peroneus quinti,	0·11
41. Peroneus brevis,	0·02
42. Peroneus longus,	0·40
43. Extensor brevis digitorum,	0·12

1, 2, 3, Plantar interossei, 0·07, 0·07, 0·06.
1, 2, 3, 4, Dorsal interossei, 0·07, 0·08, 0·07, 0·07.

destructive-distillation products of
re been made to explain its chemical
lations with other substances. This
reasons, its study is likely to prove
because it is the simplest representa-
enous bodies whose chemical history
ped in complete darkness, and is even
ared up; which form, as it were, the
ammonia bases on the one hand, and
on the other, sharing as they do the
l the active toxic and physiological
to such bodies as conine, nicotine, the
. As an unstable body, also, pyrrol
be laid down as a rule in chemical
n chemical doctrines are concerned—
y substance is, the more fruitful in
is likely to prove.

ffers many points of interest to the
has been much enhanced by the dis-
wanert,[1] that it and a closely-allied
rol-amide, are the chief products ob-
mucic acid, an acid easily obtained
r of milk) or galactose, is exposed to
importance which I venture to think
vation made by my friend Dr. Edwin
with still greater ease formed from
saccharic acid, the principal oxidation
tc. The smoothness of the reaction
uced leads to the suspicion that it is,
decomposition-product of these salts,
connected with them by molecular
I have undertaken the study of its
first-fruits of my researches I beg to
lts at which I have so far arrived.

This is the final result; but at the same time there is formed, in considerable quantity, the so-called *carbo-pyrrol-amide*, of which pyrrol is usually regarded as a direct decomposition-product:—

$$\underset{\text{Ammonium mucate.}}{C_6H_8(NH_4)_2O_8} = \underset{\text{Carbo-pyrrol-amide.}}{C_5H_6N_2O} + CO_2 + 5H_2O.$$

We may then assume that, by the action of a molecule of nascent water on carbo-pyrrol-amide, pyrrol is formed.

$$C_5H_6N_2O + H_2O = C_4H_5N + NH_3 + CO_2.$$

This view is borne out by the fact that if the amide be boiled with barium hydrate, ammonia is evolved, and the barium salt of the monobasic *carbo-pyrrolic acid* is obtained in solution (Schwanert):

$$C_5H_6N_2O + H_2O = \underset{\text{Carbo-pyrrolic acid.}}{C_4H_4N(COOH)} + NH_3;$$

which acid, at a temperature slightly above its fusing-point, splits up into pyrrol and carbonic anhydride,

$$C_4H_4N(COOH) = C_4H_5N + CO_2.$$

This decomposition may be compared with those by which phenol is produced on heating salicylic and paraoxybenzoic acids; citraconic and itaconic acids on heating aconitic acid, etc. Carbo-pyrrolic acid may then be regarded as a carboxyl derivative of pyrrol: that is, as pyrrol in which the group COOH takes the place of an atom of hydrogen.

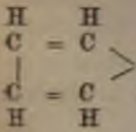
Pyrrol is a colourless pleasantly-smelling liquid, boiling at 133° C. It dissolves, although slowly, in dilute mineral acids; but all attempts to obtain simple or double salts of it have failed. The free base, however, gives with an alcoholic solution of mercuric chloride a semi-crystalline precipitate, $C_4H_5N, 2HgCl_2$, which may be compared with the precipitates produced by ammonia under the same circumstances.

Pyrrol is an extremely unstable compound. Exposed to air, it soon becomes brown, and its solutions in acids decompose, slowly in the cold, rapidly on boiling, into ammonia and the so-called *pyrrol-red*, $C_{12}H_{14}N_2O$ (Schwanert), $C_{12}H_{10}O_3$ (Limpricht). Other of its reactions will be alluded to farther on.

Respecting its chemical constitution, Kekulé ("Lehrbuch der Chemie," vol. ii., p. 408) views it as an amine, one atom of hydrogen in ammonia being displaced by the radicle C_4H_3, thus, $\left.\begin{matrix} C_4H_3 \\ H \\ H \end{matrix}\right\} N$. Wichelhaus,[2] however, has shown that this view is untenable, since it reacts neither with chloroform, with bisulphide of carbon, nor with ethyl iodide, with which reagents all primary amines combine energetically.

[2] "Berichte der deutschen Chemischen Gesellschaft," ii.

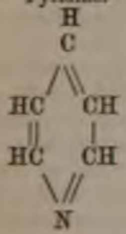
Accordingly, Baeyer and Emmerling[3] have proposed for it the constitutional formula



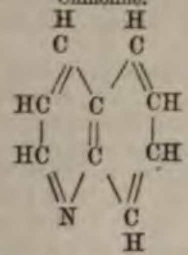
NH, which is more in accordance with its chemical characters.

Similar formulæ have been ascribed to pyridine and chinoline, in which the affinities of the nitrogen are supposed to be saturated by two carbon atoms, connected with each other through the intervention of other carbon atoms.

Pyridine.



Chinoline.



The experiments which I have to describe, while they confirm the view that pyrrol is not a primary amine, lend considerable support to the ideas of Baeyer and Emmerling regarding its constitution.

Experience having shown that an unstable body frequently acquires stability by the substitution of acid or alcoholic radicles for its displaceable hydrogen, my first efforts have been directed towards obtaining derivatives of pyrrol. Two experiments have already been made in this direction: one by Lubawin,[4] who made the interesting observation that potassium is capable of removing one atom of hydrogen in pyrrol, and that the potassium-pyrrol, C_4H_4KN so formed, when treated with ethyl iodide, furnishes potassium iodide, and a liquid the analysis of which corresponds approximately to the formula of an ethyl-pyrrol $C_4H_4(C_2H_5)N$. This he describes as a liquid possessing a turpentine-like odour, which boils between 155° and 175° C. (!), and rapidly turns red on contact with air. He considers it probable that in these bodies the potassium, and consequently the ethyl, are substituted for an atom of hydrogen in the hydrocarbon nucleus which may be assumed to exist in pyrrol regarded as an imide base $(C_4H_4)''NH$.

Köttnitz,[5] on the other hand, by the dry distillation of the mucate

[3] "Chemisches Centralblatt," 1870, p. 437.
[4] "Zeitschrift fur Chemie," [2] v. 399.
[5] "Journal für Prakt. Chemie," [2] vi. 136-156.

of aniline obtained, besides the phenyl derivatives of mucamide, two bodies of neutral character, one of which he regards as phenyl-pyrrol $C_4H_4(C_6H_5)N$. The second, which is only formed in small quantity, corresponds to the formula $C_{16}H_{14}N_2$. For this he proposes the constitutional formula $C_4H_4 \left< \begin{matrix} NC_6H_5 \\ NC_6H_5 \end{matrix} \right.$. From toluidine mucate he obtained only the homologue of this latter substance, $C_{18}H_{18}N_2$, but no tolyl-pyrrol. In phenyl-pyrrol it is highly probable, from the nature of the reaction, that the group C_6H_5 remains in connexion with the nitrogen, and Köttnitz argues, by analogy, that the same position must be assigned to the residue ethyl in Lubawin's ethyl-pyrrol. That this cannot be the case will be rendered evident by the results of my experiments.

The plan of procedure which I have adopted is essentially that of Köttnitz. I have, however, experimented in addition with secondary and tertiary monamines, in view of the possibility of obtaining di- and tri-derivatives of pyrrol. In this respect my expectations have not been fulfilled, and thus the view of Wichelhaus and of Baeyer and Emmerling, viz., that pyrrol does not contain the residue NH_2, has received strong confirmation. I have, however, succeeded in producing a series of bases derived from pyrrol, besides other allied bodies which have no analogues amongst those described by Köttnitz. These I proceed to describe.

Distillation of Ethylammonium Mucate.

This salt is easily formed by bringing together solutions of ethylamine and mucic acid in equivalent proportions. The acid is rapidly dissolved with development of heat, and on evaporation and *slow cooling* the mucate is obtained in large, transparent, slightly oblique, rhombic prisms, which are freely soluble in water, less so in alcohol. These appear to correspond to the formula $C_6H_{10}O_8 \cdot 2NH_2(C_2H_5) + 8\,H_2O$. They effloresce on exposure to air, quickly losing the whole of their water of crystallization. If dried in the water bath, the salt experiences slight dissociation, some ethylia being given off. The same occurs when a concentrated solution of it is boiled. The crystals are, therefore, best dried *in vacuo* over sulphuric acid. When crystallized from water at a high temperature, or from strong alcohol, the salt is deposited in the anhydrous form. A determination of the ethylia evolved on heating the dried salt with caustic potash proved it to have the composition $C_6H_{10}O_8, 2NH_2C_2H_5$.

Exposed to heat, mucate of ethylia first melts, and then decomposes with intumescence. To obtain its distillation-products direct heating over the lamp is not advisable. The operation is advantageously conducted in a long-bodied retort, or, better still, in a tall and thin-sided bottle, secured in a paraffin bath furnished with a

, few attempts seem to have been made to explain its chemical tution, or to ascertain its relations with other substances. This arkable, because, for many reasons, its study is likely to prove erest; and chiefly, indeed, because it is the simplest representa-f that large class of nitrogenous bodies whose chemical history until quite recently, enveloped in complete darkness, and is even y no means satisfactorily cleared up; which form, as it were, the cting link between the true ammonia bases on the one hand, and ydrocyanic ethers or nitriles on the other, sharing as they do the characters of the first, and the active toxic and physiological rties of the second. I allude to such bodies as conine, nicotine, the ine and chinoline series, etc. As an unstable body, also, pyrrol s our attention, for it may be laid down as a rule in chemical rch—at least so far as modern chemical doctrines are concerned—he more prone to change any substance is, the more fruitful in etic results its examination is likely to prove.

ut while in itself pyrrol offers many points of interest to the ific chemist, its importance has been much enhanced by the dis-y, due to Malaguti and Schwanert,[1] that it and a closely-allied ance, the so-called *carbo-pyrrol-amide,* are the chief products ob-l when the ammonia salt of mucic acid, an acid easily obtained e oxidation of lactose (sugar of milk) or galactose, is exposed to perature above 220° C.; an importance which I venture to think ch heightened by the observation made by my friend Dr. Edwin er and myself, that it is with still greater ease formed from mmonia salt of the isomeric saccharic acid, the principal oxidation ct of ordinary cane sugar, etc. The smoothness of the reaction hich it is in both cases produced leads to the suspicion that it is, e true sense of the word, a decomposition-product of these salts, hence that it is intimately connected with them by molecular ons. For these reasons I have undertaken the study of its norphoses, etc., and as the first-fruits of my researches I beg to efore the Academy the results at which I have so far arrived.

he reaction in virtue of which pyrrol is obtained from ammonium te is very simple, and may be thus represented:—

The liquid of low boiling point, after a few rectifications, distilled at 131°, and on analysis yielded the following results:—

	Experiment.			Calculated for
	I.	II.	III.	$C_4H_4(C_2H_5)N$.
C =	75·92	—	—	75·79
H =	9·71	—	—	9·47
N =	—	14·58	14·69	14·83

That it was an ethyl-derivative of pyrrol is thus proved by its analysis, and the circumstances under which it was produced.

Ethyl-pyrrol is a colourless liquid of sp. gr. ·9042 at 10° C., ·8936 at 15° C. It possesses an odour closely resembling, but still distinguishable from that of pyrrol. Like that body, it is very sparingly soluble in cold water or in dilute acids, easily in concentrated hydrochloric, nitric, or acetic acids. Sulphuric acid also dissolves it, giving a dark-coloured solution which strikes a deep black with potassium bichromate. Its vapour, like that of pyrrol, colours fir-wood moistened with hydrochloric acid an intense crimson. With alcoholic mercuric chloride it gives a white precipitate. Its alcoholic solution gives a dark colour with platinum tetrachloride, but no precipitate, even on standing for twenty-four hours (difference from pyrrol).

By their behaviour with concentrated acids the two bases are strikingly distinguished. When pyrrol is boiled with strong hydrochloric acid, it is converted in a few seconds into a jelly-like mass of pyrrol-red; whereas the ethyl-derivative may be boiled for some time with the concentrated acid, and afterwards, by dilution, precipitated unaltered. Both pyrrol and ethyl-pyrrol are oxydized with explosive violence on gentle warming with strong nitric acid; and in the cold the former is quickly converted into pyrrol-red. But if ethyl-pyrrol be dissolved in a minimum of cold nitric acid, the mixture on standing for some time deposits a thick, oily liquid, which may be redissolved by a slight addition of acid, only to reappear soon. When freed from nitric acid and pyrrol, by washing with water, this liquid does not give the fir-wood reaction, either alone or when heated with potash. It is in all probability a nitro-derivative. I propose to examine it further.

If bromine be added to ethyl-pyrrol or to its solution in ether, chloroform, acetic acid, etc., the mixture becomes black and tarry, giving off hydrobromic acid. But if a freshly-prepared and cooled solution of bromine in alcohol be cautiously added to an alcoholic solution of ethyl-pyrrol, at a certain point, the latter deposits crystals of a compound, melting about 90° C., quite insoluble in water, and but sparingly taken up by strong spirit. It is probably an addition product; but I have not yet obtained it in sufficient quantity to examine it completely. Under no circumstances have I been able to obtain such a body from pyrrol.

The liquid boiling at 269°–270°, when pure, solidifies slowly to a mass of long and thick prisms, which are more rapidly but not so

-formed crystal is introduced into it.
small quantities of foreign bodies
ation to an extraordinary degree, or
boiling water this substance is tole-
cooling in the form of oily drops,
It melts at 43°–44° C. when dry;
mperature: wherefore it is necessary
ing it with the fingers.
ng results:—

	Calculated for diethyl-carbo-pyrrol-amide. $C_5H_4(C_2H_5)_2N_2O$.
. . . .	65·06
. . . .	8·43
. . . .	16·86

thyl-derivative of Schwanert's carbo-
y therefore be written :—$C_4H_3(NC_2H_5)$
ably stable body. When pure it is
y be distilled unaltered. Its behaviour
rolonged boiling with aqueous potash
t it in the slightest degree, and even
rge excess of alcoholic potash, nearly
d unaltered. Strong acids dissolve it
on dilution. The hydrochloric and
be boiled without decomposition en-

paringly soluble in cold alcohol, which
ammonium mucate is distilled, is dis-
precipitated on dilution, and, in fact,
amide. In water it is completely in-
the formula $C_{12}H_{19}N_3O_2$:—

	Calculated for $C_{12}H_{19}N_3O_2$.
. . . .	60·76
. . . .	8·14
. . . .	17·72

ly resists decomposition. By careful
altered, and may be boiled with either
thout suffering any change. Heated in
partially decomposed, giving off ethyl-
xhibits the fir-wood reaction, and is
rrol.
en during the distillation of ethyl-
following; it will be convenient to

present mucic acid as the dicarboxyl derivative of a radicle $C_4H_{10}O_4$:—

Ethyl-pyrrol.

(1) $C_4H_8O_42COON(C_2H_5)H_3 = C_4H_4(C_2H_5)N + 2CO_2 + NH_2C_2H_5 + 4H_2O.$

Diethyl-carbo-pyrrol-amide.

(2) $C_4H_8O_42COON(C_2H_5)H_3 = C_5H_4(C_2H_5)_2N_2O + CO_2 + 5H_2O.$

In order to explain the formation of the third product, $C_{12}H_{19}N_3O_3$, we must assume that a molecule of ethylia, liberated according to equation (1), enters into reaction with a molecule of unaltered mucate, forming water and the new body :—

(3) $C_4H_8O_42COON(C_2H_5)H_3 + N(C_2H_5)H_2 = C_{12}H_{19}N_3O_2 + 6H_2O.$

The quantity of this latter produced appears to increase with the purity and dryness of the salt operated on, and the slowness with which the distillation is conducted. The presence of even a small quantity of di- or tri-ethylamine prevents its appearance altogether. This is readily explained, since I have found that on heating a mixture of ethylium and diethylium mucate, the base expelled in the free state consists chiefly of diethylia, which evidently could not enter into reaction (3).

In fact, the yield of ethyl-pyrrol under these circumstances is considerably greater than when the pure primary amine is employed.

In the case of a double salt of primary and secondary ethyl-ammonium, for example, the reaction appears to take place principally, though not quantitatively, according to the following equation :—

$$C_4H_8O_4\begin{cases}COON(C_2H_5)H_3\\COON(C_2H_5)_2H_2\end{cases} = C_4H_4(C_2H_5)N + 2CO_2 + N(C_2H_5)_2H + 4H_2O.$$

For the preparation of ethyl-pyrrol, then, the mixture of bases furnished by digesting ethyl-iodide with ammonia, after removal of the ammonia, may be used with advantage.

The relations of the body $C_{12}H_{19}N_3O_2$ will be discussed further on.

Distillation of Methylammonium Mucate.

This salt is also easily prepared by shaking up the requisite weight of mucic acid with a somewhat dilute methylamine solution. The mixture becomes warm, and if sufficient water is present the acid is completely dissolved. On evaporation the mucate is obtained in anhydrous crystals. It is much less soluble than the corresponding ethylia salt, and may, with little loss, be crystallized from boiling water. Even boiling alcohol scarcely dissolves it.

Exposed to a temperature of 180°–190° C. in the apparatus previously described, it is decomposed with intumescence and evolution of carbonic anhydride, and the production of a mixed aqueous and oily

s of *methyl-pyrrol*, holding in solution *bo-pyrrol-amide*. The two are easily rashed and dried mixture by fractional f the amide, however, remains in the e easily extracted by distillation at m, when it comes over as a heavy oil, e water which accompanies it, large are deposited after it has remained

on is terminated, the black residue in alcohol, it will be found to dissolve on, on cooling, deposits small hard hyl analogue of the body $C_{12}H_{19}N_3O_2$. rystals in a form suitable for analysis llness of their quantity has prevented and chemical characters with exact-

s, mobile, and volatile liquid, of specific iling point 112°–113° C.; the latter is yrrol. On exposure to air it slowly ecals at once those of pyrrol and of hable from both. With nitric acid, behaves exactly like the latter. Its the following analysis:—

	Calculated for $C_4H_4(CH_3)N$.
. . . .	74·07
. . . .	8·64
. . . .	17·28.

le is a crystalline body, melting at t 260° C. In all its chemical characters ethyl compound, exhibiting the same ds and alkalies. It is, however, much or cold. When caused to crystallize rated solution it appears in thin glis- eparates spontaneously it forms hard Its analysis yielded the following re-

	Calculated for $C_5H_4(CH_3)_2N_2O$.
. . . .	60·87
. . . .	7·24
. . . .	20·29.

liate between that of carbo-pyrrol-amide arbo-pyrrol-amide (44° C.).

Distillation of Amylammonium Mucate.

Like its congeners, this salt is easily prepared by bringing together an aqueous solution of amylamine[a] and mucic acid. On evaporation, it is obtained as a confusedly crystalline mass, exceedingly soluble in water and alcohol, and difficult to obtain in well-defined crystals. I have therefore not examined it particularly, but have submitted the salt, after thorough drying on the water bath, to distillation. This was conducted as already described, but towards the close of the operation the bath was allowed to attain a temperature of 200° C., although this was by no means necessary for the decomposition, which took place between 160° and 180°. The distillate was chiefly water, holding in solution amylammonium carbonate, on the surface of which floated a small quantity of a very agreeably-smelling oil, which was separated, purified, and dried, as described for ethyl-pyrrol. When distilled, it commenced to boil at 179° C.: the thermometer rose quickly to 188° C., when nothing more came over. On cooling, the residue solidified. The liquid which passed over between 179°–188° C., after standing for some days, deposited a few needles, and on redistillation again gave a residue which solidified. To free it from this crystalline body the rectification had to be many times repeated. Finally I succeeded in isolating a colourless liquid, of a fragrant, but somewhat oppressive odour. Sp. gr. (at 16° C.), ·8786. It boiled between 180° C. and 184°. Analysis yielded results agreeing with the formula $C_4H_4(C_5H_{11})N$.

Experiment.	Calculated for $C_4H_4(C_5H_{11})N$.
C = 78·83	78·83
H = 11·28	10·95.

The yield from 25 grams. of amylamine (the quantity which I employed) only equalled a few cubic centimeters. I did not, therefore, make a nitrogen determination, the nature of the liquid being already sufficiently established. It could be no other than amyl-pyrrol. In its reactions, so far as I have examined them, it resembles the methyl and ethyl derivatives. It is, however, nearly insoluble in water, and retains its freedom from colour for a long time.

The residue from the distillation of the mucate consisted almost entirely of diamyl-carbo-pyrrol-amide, which was indeed by far the most abundant product. I did not examine it for the amyl analogue

[a] Amylamine may be most advantageously prepared by Wurtz's process from cyanate of silver and amyl iodide, since Grimm has taught us an easy and rapid method of procuring the latter. For the preparation of cyanates, see a process which I have given ("Chemical News," vol. xxxii. p. 99). The formation of amyl cyanate and cyanurate (almost a quantitative reaction) takes place in a few hours in sealed tubes at 160° C. I have also found that amyl bromide, contrary to what is usually stated, when digested with alcoholic ammonia for a couple of days at 100° C., furnishes a considerable quantity of the primary amine.

beautifully formed when a ready-formed crystal is introduced into it. But the presence of even very small quantities of foreign bodies suffices to retard the crystallization to an extraordinary degree, or even to hinder it altogether. In boiling water this substance is tolerably soluble, and separates on cooling in the form of oily drops, which after some days solidify. It melts at 43°–44° C. when dry; when moist, at a much lower temperature: wherefore it is necessary to avoid breathing on it or touching it with the fingers.

Its analysis gave the following results:—

Experiment.	Calculated for diethyl-carbo-pyrrol-amide. $C_5H_4(C_2H_5)_2N_2O$.
C = 64·56	65·06
H = Lost	8·43
N = 16·68	16·86

It is without doubt a diethyl-derivative of Schwanert's carbo-pyrrol-amide. Its formula may therefore be written:—$C_4H_3(NC_2H_5)(CONHC_2H_5)$. It is a remarkably stable body. When pure it is quite permanent in air, and may be distilled unaltered. Its behaviour towards alkalies is peculiar. Prolonged boiling with aqueous potash or barium hydrate fails to affect it in the slightest degree, and even after boiling for hours with a large excess of alcoholic potash, nearly the whole of it may be recovered unaltered. Strong acids dissolve it easily, and yield it unchanged on dilution. The hydrochloric and acetic acid solutions may even be boiled without decomposition ensuing.

The crystalline substance, sparingly soluble in cold alcohol, which is left in the retort when ethylammonium mucate is distilled, is dissolved by concentrated acids, precipitated on dilution, and, in fact, presents all the characters of an amide. In water it is completely insoluble. Analysis conducted to the formula $C_{12}H_{19}N_3O_2$:—

Experiment. I.	Experiment. II.	Calculated for $C_{12}H_{19}N_3O_2$.
C = 60· 8	60·51	60·76
H = 8·28	8·51	8·14
N = 17·88	17·55	17·72

This peculiar body strongly resists decomposition. By careful heating it may be sublimed unaltered, and may be boiled with either aqueous or alcoholic potash, without suffering any change. Heated in a test-tube with soda-lime, it is partially decomposed, giving off ethylamine and a vapour which exhibits the fir-wood reaction, and is therefore, presumably, ethyl-pyrrol.

The changes occurring then during the distillation of ethylammonium mucate are the following; it will be convenient to

they are theoretically impossible if its constitution is truly represented by the formula

$$\left.\begin{array}{c} H\quad H \\ C = C \\ | \\ C = C \\ H\quad H \end{array}\right\rangle NH.$$

As will be seen, I have not obtained them; and this fact, I think, tends to confirm the theory of Baeyer. I have experimented with the mucates of diethyl and diamyl-amine.

Distillation of Diethylammonium Mucate.

This salt is obtained by dissolving mucic acid in solution of diethylamine, evaporating and crystallizing. It contains water, and is extremely soluble both in that liquid and in alcohol. When heated in the paraffin bath it decomposed with intumescence and evolution of carbonic anhydride, like the primary salt, but at a somewhat lower temperature. The distillate, as before, was a watery solution of diethylammonium carbonate, on the surface of which floated a small quantity of an oily liquid, possessing the odour, boiling point, and other characters of ethyl-pyrrol. This was evidently due to the presence of some primary amine in the diethylamine used.[7]

The retort residue was a black, carbonaceous mass, burning with flame, from which neither by solvents nor by further heating could anything suitable for analysis be extracted.

Distillation of Diamylammonium Mucate.

Easily formed by the direct union of diamylamine[8] and mucic acid. The resulting compound is freely soluble in water and alcohol. The distillation, which was slowly conducted over the naked flame, in every respect resembled that of the preceding salt. Owing

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[7] The diethylamine was prepared from diethyloxamic ether, boiling within a few degrees of 264° C. As obtained in the separation of the ammonia bases by oxalic ether, it is impossible (at least on the small scale) to separate it from simultaneously-formed monoethyloxamic ether (Wallach). Hence the presence of ethylia in the diethylia extracted from it by caustic potash. Baeyer ("Berichte," vii. 963) has now shown that by the action of caustic soda on nitroso-diethyl-aniline and nitroso-dimethyl-aniline, dimethylamine and diethylamine may be obtained in a state of absolute purity. But as this method, the only really satisfactory one, is somewhat costly, I propose to separate the primary and secondary bases by the distillation of their mucates. If the quantity of primary base be small, the secondary base will alone be liberated in the free state. I am not, however, prepared with analytical proofs.

[8] Diamylamine is usually stated, on the authority of its discoverer, Hofmann, to boil at 170° C. I have found, however, that it (that is, the variety prepared from ordinary amylic alcohol) boils at 185°-187°. That which I employed in these experiments boiled within a few degrees of this temperature, and yet evidently contained much amylamine (B.P. 95° C.). I am convinced that the complete separation of the primary, secondary, and tertiary amylamines by fractional distillation is as little feasible as that of the ethyl bases by the same process.

llate. The oily layer consists of *methyl-pyrrol*, holding in solution all quantity of *dimethyl-carbo-pyrrol-amide*. The two are easily rated from the thoroughly washed and dried mixture by fractional llation. The greater part of the amide, however, remains in the mposing-retort, and may be easily extracted by distillation at t 200° C. in a current of steam, when it comes over as a heavy oil, h soon solidifies. From the water which accompanies it, large beautifully-formed crystals are deposited after it has remained sturbed for a few days.

f, after the second distillation is terminated, the black residue in retort be treated with warm alcohol, it will be found to dissolve st completely; the solution, on cooling, deposits small hard tals, which may be the methyl analogue of the body $C_{12}H_{19}N_3O_2$. my efforts to obtain these crystals in a form suitable for analysis e as yet failed, and the smallness of their quantity has prevented ascertaining their physical and chemical characters with exact-.

Methyl-pyrrol is a colourless, mobile, and volatile liquid, of specific rity ·9203 at 10° C., and boiling point 112°–113° C.; the latter is -21° lower than that of pyrrol. On exposure to air it slowly mes brown. Its odour recals at once those of pyrrol and of l-pyrrol, but is distinguishable from both. With nitric acid, nine, and other reagents, it behaves exactly like the latter. Its position is clearly proved by the following analysis:—

Experiment.	Calculated for $C_4H_4(CH_3)N$.
C = 73·9	74·07
H = 8·91	8·64
N = 17·26	17·28.

Dimethyl-carbo-pyrrol-amide is a crystalline body, melting at -90° C., and boiling at about 260° C. In all its chemical characters esembles the corresponding ethyl compound, exhibiting the same ifference towards strong acids and alkalies. It is, however, much re soluble in water, hot or cold. When caused to crystallize idly from its cold supersaturated solution it appears in thin glis-ing scales; but when it separates spontaneously it forms hard nsparent massive prisms. Its analysis yielded the following re-ts:—

Experiment.	Calculated for $C_5H_4(CH_3)_2N_2O$.
C = 60·62	60·87
H = 7·58	7·24
N = 20·24	20·29.

Its fusing point is intermediate between that of carbo-pyrrol-amide 3° C.) and that of diethyl-carbo-pyrrol-amide (44° C.).

The above boiling points are uncorrected. In the case of amyl-pyrrol, since the quantity of liquid was small, and the thermometer by no means all that could be desired, the correction to be applied would in all probability amount to five or six degrees, which would bring its boiling point into still closer conformity with Kopp's law.

On the other hand, the ethyl-pyrrol obtained by the action of ethyl iodide on potassium-pyrrol is stated by Lubawin, its discoverer, to boil between 155° and 175° C. From the description given of it, the compound was manifestly in an impure state; but if obtained free from foreign matter it would, no doubt, be found to have the boiling point $133 + 19 \times 2 = 171°$ C. It is, in short, a true homologue of pyrrol. The isomerism of these two ethyl-derivatives may be explained by the following constitutional schemes:

Pyrrol.	Ethyl-pyrrol (Lubawin).	Ethyl-pyrrol.
$(C_4H_4) = N$	$H(C_4H_3\,(C_2H_5)\,) = NH$	$(C_4H_4) = N\,(C_2H_5)$.

We may, I think, reject as disproved the surmise of Köttnitz, that in Lubawin's ethyl-pyrrol the ethyl is united to the nitrogen.

If these formulæ are correct, it should be possible to substitute in the compound $C_4H_4N\,(C_2H_5)$, by Lubawin's process, an ethyl group for one of the nuclear atoms of hydrogen, and so to arrive at the base $C_4H_3\,(C_2H_5)\,NC_2H_5$. I have, in fact, observed that potassium acts on ethyl-pyrrol, evolving hydrogen: but the action is extremely slow, whereas pyrrol is violently attacked by the metal. The slight action in the former case may, possibly, be due to the presence of impurities. On this point I cannot at present speak with certainty, the quantity of liquid in my possession not permitting of a satisfactory solution of it.

In planning methods for obtaining derivatives of pyrrol, it must be borne in mind that the two ethyl compounds just mentioned by no means represent all the different modes of substitution of which the pyrrol molecule is theoretically susceptible. If we apply here the beautiful ideas of Kekulé on the isomerism of benzol derivatives, it will be evident, pre-supposing the correctness of Baeyer's formula, that the introduction into the molecule of any given radicle might give rise to three isomeric bodies, accordingly as it displaced what we may call the imidic hydrogen, or one of either of the pairs of hydrogen atoms adjacent to, and remote from, the nitrogen. Here we have indicated the existence of a large number of derivatives, some of which may yet prove of therapeutic importance. From experiments on which I am at present engaged, in conjunction with my friend Dr. Lapper, it is evident that the toxic properties of pyrrol, which are powerful, are modified in an interesting manner by the substitution of alcoholic groups for its imidic hydrogen. So far our results afford a striking parallel to the interesting observations of Crum-Brown on the physiological action of strychnia and aconitia, and their derivatives. Our experiments shall form the subject of a future communication.

e relationship which subsists between
ay be, is still obscure. Nevertheless,
mpound $C_{12}H_{19}N_3O_2$ is calculated to
this body on heating with alkalies
ume the pyrrol nucleus to exist in it
is then most easily explained, if we
-carbo-pyrrol-amide in containing the
l of once.

-amide. New body.
(C$_2$H$_5$) $C_4H_2(CONHC_2H_5)_2N(C_2H_5)$;

cordance with its chemical behaviour,
e name triethyl-dicarbo-pyrrol-amide.
fore we can regard this relationship
hink I can show that at least great
collect the results of certain isolated
ndeavour to fit them together.
on of hydrobromic acid on mucic acid
btained a bibasic acid which he terms
ars to mucic acid the relation of an

$3H_2O = C_6H_4O_5$.

mpels us to write its formula C_4H_2O
eover, in perfect accord with its be-
temperature is rapidly raised it breaks
nto the monobasic pyromucic acid and

$C_4H_3O(COOH) + CO_2$.

richt[10] showed that when this latter
also be obtained directly by heating
a-lime, it again parts with CO_2, and
H_4O, to which the inapt name *tetra-*

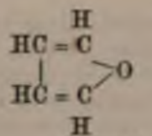
$H) = C_4H_4O + CO_2$.

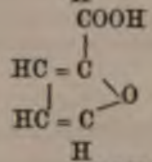
are such as to show clearly that it does
at all; that it is, in fact, neither an
ht, therefore, assigns to it the formula

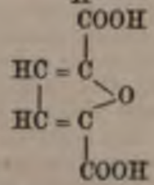
s then a mono-carboxyl, and Fittig's

this tetraphenol.

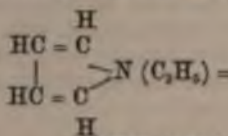
Chemischen Gesellschaft," ix. 1198.
der Pharmacie," band clxv., 253.

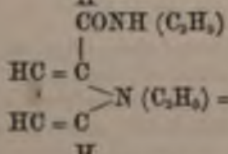
 = Tetraphenol.

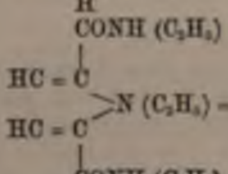
 = Pyromucic acid.

 = Dehydromucic (Fittig's) acid.

If we now, employing Baeyer's formula for pyrrol, write the three ethyl derivatives, on the view stated above, the relation between them and the tetraphenol derivatives is at once apparent :

 = Ethyl-pyrrol.

 = Diethyl-carbo-pyrrol-amide.

 = Triethyl-carbo-pyrrol-amide.

We have now got the clue to the mechanism of the reactions by which these bodies are obtained from mucic acid. Crum-Brown and Limpricht have both obtained from mucic acid bodies whose formation can only be accounted for on the hypothesis that it (mucic acid) is a derivative of normal adipic acid, the oxidation product of normal hexane, $C_6 H_{14}$. It must then have the constitution—

$\dot{C} - \dot{C} - COOH$

ted as unsaturated in the diagram, emaining four by hydroxyl (OH) of these hydroxyl groups we know with still greater certainty a deri- ly their position which determines nd consequently of galactose and

phenol and pyrrol we need for roups connected with the carbon groups. These may be supposed to

(1)

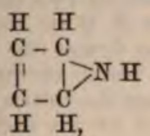
yl-pyrrol fragment.

$$\begin{array}{l} = C \\ \quad > N\,(C_2H_5) + 2\,H_2O \qquad (2) \\ = C \end{array}$$

group persists, we get pyromucic acid is the result. Similarly, if up persists, becoming amidated o-pyrrol-amide; if both, we get

ow how the remaining hydroxyl ucic acid, whatever their arrange-

ig doubts the connexion of mucic even if it should be shown that xist as lateral and not as terminal emain, in principle, unaltered.
it should be found that mucic acid

the form 

IV.—On Glaciation by Sea Ice. By Edward L. Moss, M. D. R. N., late Surgeon H.M.S. "Alert."

[Read, January 22, 1877.]

The existence of a glacier implies the co-existence of so many related phenomena, that the integrity of the evidence adduced in proof of it becomes of proportionate importance.

Rounding and furrowing of rock surfaces are amongst the most familiar and characteristic records left by the flow of a glacier, and much attention has naturally been directed to the possibility of similar markings being produced by other causes.

Apart from the planing and striating resulting from agencies unconnected with ice action, and narrowing the subject to the effects of ice alone, it has been very generally admitted that either icebergs, sea ice, or river ice are, under favourable circumstances, capable of rounding off rocks into the "roches moutonnés." On the other hand, much has been written both to prove and to disprove the production of *glacial scratchings* by such agencies.

So long ago as 1847, Forchhammer, writing of the scratched and polished rock surfaces in Denmark, pointed out that sea ice occasionally forced on shore by strong gales carried boulders and *debris* with it, and could hardly fail to striate the rocks over which it passed. Since that time Sir Charles Lyell has referred certain markings found by him in the Bay of Fundy to such action, and Dr. Robert Brown, and Mr. Campbell have dwelt on the probability of its occurrence.

The shore of the Polar Sea in north latitude 82·27, where H. M. S. Alert passed the winter of 1875–76, is everywhere lined with a barrier reef of ice masses broken off from the floes and grounded along the beach in from five to fifteen or more fathoms of water. The ice thus grounded slowly wastes summer after summer from cubical into conical and "mushroom" shapes, and as it wastes it gets forced further and further towards the ice foot by the incalculably great pressure of the Polar pack. It occasionally happens that such masses, during the rough handling they are subjected to every year in the brief disruption of summer, or during the five months in which the floating floes retain some motion, get overturned and thus expose the under surfaces which had lain in contact with the bottom.

Specimens of two such surfaces existed in the immediate neighbourhood of H. M. S. Alert as she lay frozen in her winter quarters. One of them formed the side of an ice cave under a large floeberg half a mile astern of the ship. The ice of the surface which had rested against the bottom was easily distinguished from the clear blue ice round it by the dark colour caused by the mud and fine sand it contained, and every part of it was chiselled into deep and well-marked parallel grooves and ridges, such as, had they existed in rock

aining fourth, a space of twenty feet
ormer case, black with mud, present-
black marble, and was in every part
shed parallel grooves—some of them
idge to ridge.
almost in the same direction, and
whole width of the ice. The third
d both the others at an angle of 20°.
he source from which the grooving
ntly continuous; nothing else could
enty feet long.
g had been confined to the ice alone,
have been forthcoming; and I would
llustration to an excellent photograph
ite, an officer of H. M. S. Alert, but
in in time for exhibition here, from
y, in whose hands the negative was

re not confined to the ice alone, but
rfaces of a number of stones firmly
g from it in proportion to their hard-
d I have now the pleasure of exhibit-
t several of them show grooves and
rce had not been known, would have
handiwork of a glacier.
s to the pelagic character of the ice,
least salt part was found to contain
ether beyond the limits of land ice,
lar floes around it.

V.—Reports from the Chemical Laboratory of Trinity College, Dublin. By J. Emerson Reynolds, M. D., Professor of Chemistry, University of Dublin.

No. 2.—On the Composition of Lievrite, as determined by Mr. Early's method.

[Read, January 22, 1877.]

Of the several methods which have been devised for the analysis of ferroso-ferric silicates, that which has been published by Mr. William Early,[1] Demonstrator of Chemistry in this laboratory, is probably the most easily managed. The advantages attending its use are chiefly felt in analyzing silicates, which are either insoluble in, or attacked with difficulty by, the ordinary acids; but it can also be used with great convenience in the analysis of silicate easily acted upon by acids.

Lievrite is a silicate belonging to the latter class; and as the formula of the mineral is by no means definitely fixed, I requested Mr. Early to analyze by his method a portion of a particularly fine crystal which I obtained some time ago from the well-known Elba locality, our chief aim being to determine with precision the relative amounts to ferrous and ferric compounds present in the specimen.

The analysis was conducted in the following manner:—

1·54 grm. of the finely and recently powdered mineral was mixed with 20 cubic centims. of hydrofluoric acid (containing 20 per cent. of real acid); and the mixture was boiled for five minutes in a deep platinum crucible with a rather loosely fitting cover. 10 cubic centims. of diluted sulphuric acid (1 part to 2 of water) were then added, and the boiling continued for a few minutes. The contents of the crucible were then washed into a flask with air-free water, and the amount of iron in the ferrous condition determined as rapidly as possible by standard potassic permanganate solution. Another quantity of the mineral was acted upon by strong hydrochloric acid; perfect decomposition was effected, and a gelatinous mass formed; the product was evaporated to dryness, and the silica separated in the usual way. The acid filtrate from the insoluble silica was then saturated with chlorine gas, and ammonia afterwards added in slight excess; the mixture produced was then boiled in a closely covered beaker in order to remove the excess of ammonia, the solution rapidly filtered, and the precipitate collected and ignited with the usual precautions and weighed. The product contained all the iron as ferric oxide, the alumina, the manganese as Mn_3O_4, and a trace of silica. The silica was separated from this mixture by hydrochloric acid; and the filtrate was subjected to the double

[1] "Chemical News" for October 9th, 1874.

$$HOOC-\dot{\underset{\cdot}{C}}-\dot{\underset{\cdot}{C}}-\dot{\underset{\cdot}{C}}-\dot{\underset{\cdot}{C}}-COOH$$

four of the carbon affinities, represented as unsaturated in the diagram, being satisfied by hydrogen, the remaining four by hydroxyl (OH) groups. Of the exact arrangement of these hydroxyl groups we know nothing, but since saccharic acid is with still greater certainty a derivative of normal hexane, it is probably their position which determines the isomerism of the two acids, and consequently of galactose and glucose.

To explain the genesis of tetraphenol and pyrrol we need for the present only consider the OH groups connected with the carbon atoms which lie next the carboxyl groups. These may be supposed to enter into reaction as follows:—

Tetraphenol fragment.

$$\begin{array}{l} =\overset{|}{C}\,(OH) \\ =C\,(OH) \end{array} = \begin{array}{l} =\overset{|}{C} \\ =C \end{array}\!\!>O + H_2O \qquad (1)$$

Ethyl-pyrrol fragment.

$$\begin{array}{l} =\overset{|}{C}\,(OH) \\ =\underset{|}{C}\,(OH) \end{array} + NH_2\,(C_2H_5) = \begin{array}{l} =\overset{|}{C} \\ =C \end{array}\!\!>N\,(C_2H_5) + 2\,H_2O \qquad (2)$$

If in reaction (1) one COOH group persists, we get pyromucic acid; if both remain, dehydromucic acid is the result. Similarly, if in reaction (2) one COOH group persists, becoming amidated ($CONHC_2H_5$), we get diethyl-carbo-pyrrol-amide; if both, we get the triethyl-dicarbo-pyrrol-amide.

A little consideration will show how the remaining hydroxyl groups could be eliminated from mucic acid, whatever their arrangement may be.

It should be observed that Fittig doubts the connexion of mucic acid with normal adipic acid. But even if it should be shown that one or both of the COOH groups exist as lateral and not as terminal chains, the above explanation will remain, in principle, unaltered.

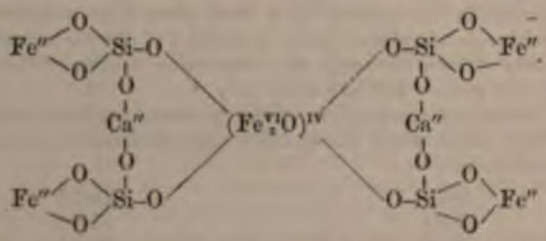
This would also be the case if it should be found that mucic acid is a derivative of the group—

$$\begin{array}{c} -\overset{|}{C}-\overset{|}{C}- \\ -\underset{|}{C}-\overset{|}{\underset{|}{C}}- \end{array} \quad \text{and pyrrol of the form} \quad \begin{array}{c} H\ \ H \\ C-C \\ \Vert\quad |\!>NH \\ C-C \\ H\ \ H, \end{array}$$

which is by no means impossible.

Mr. Early's analysis of the mineral agrees in all essential particulars with those of Rammelsberg and von Kobell, though both those distinguished observers found slightly more iron in the ferric condition. A comparison of the analyses of different specimens of Lievrite by Rammelsberg, von Kobell, Städeler,[1] and Early prove that there is little variation in the proportion of Fe_2^{vi} to Fe''; I am therefore disposed to regard the former as an essential constituent of the mineral, rather than as a product of the oxidation of a calcio-ferrous silicate. That the mineral oxidizes in time there can be no doubt; but I have had a number of specimens of Lievrite under observation for nearly ten years, and though two of them were placed in a rather damp case, they suffered comparatively slight superficial oxidation.

If, then, we admit that Lievrite is essentially a dicalcic-ferroso-ferric silicate, we can assign to it the following symmetrical formula:—



This formula has at least the merit of indicating that the function of the ferric group is probably one of considerable importance, and that, so far from being regarded as an accidental constituent of the mineral, it ought to be considered one of the most important components of the molecule of the compound.

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[1] See Dana's "System of Mineralogy," 5th edition, p. 296.

[EXA]MINE THE INFLUENCE OF THE MOLECULAR [...]ER MOTION WHEN IN ROTATION, AND IN [...]port, Part I. By HENRY HENNESSY, [...]essor of Applied Mathematics in the [...]r Ireland.

[...]ebruary 12, 1877.]

[...]ave long since completely established [...] as strictly exhibiting the physical pro[...]ommonly defined in almost all treatises [...]nics as a perfect fluid.

[...]icles are supposed to be free to move [...]mallest application of force—in other [...]e absolutely smooth, and totally des[...]ch qualities, their motions would be [...]mselves, and almost free from friction [...]id substances. The practical experience [...] since clearly shown, that the flow of [...]ery notable resistances, which observers [...]the liquids against the surfaces of the [...]y were moving. More recently, mathe[...]ers have been led to recognise a kind of [...]ds depending entirely on the molecular [...]lves, and to this kind of resistance the [...]n generally applied. If this term is to [...]me that care should be taken to clearly [...]d of resistance to motion and that of [...]derstood between solid bodies. If two [...]lids of the same form and molecular char[...]for instance, two sheets of glass, such [...]on of one upon the other exists, that [...]shear away. The resistance to motion [...] due to cohesion. If two dissimilarly [...]ved in contact, experience shows that [...]e motion meets with little resistance, but [...]sistance may be very considerable. In [...]expended in causing the asperities of one [...] away the asperities of the other, and [...]ction is spoken of as synonymous with [...]dence for assuming that such conditions [...] a fluid as to justify us in classifying the [...]on as identical with this kind of force. [...]na of the molecular statics of liquids pre[...]henomena of capillary attraction, and in [...]Plateau on masses of liquid free from the

action of gravity, we must conclude that, although the intermobility of the molecules is the fundamental property of all liquids, this property is accompanied by a considerable amount of cohesion. When liquids possess cohesion in a high degree, they are said to be viscid. As far as my observations have gone, I have been led to conclude that the resistance to liquid motion, designated as internal friction, arises almost entirely from cohesion of their particles, and that it might be more simply and more correctly called *viscidity*.[1]

The paramount influence exercised by the motions of fluids in many of the most remarkable phenomena of nature has long since induced observers to undertake experimental researches with reference to the resistances of fluids. Coulomb[2] was the first who made systematic experiments with a view to elucidate the influence of cohesion on the resistance of fluids. His researches appear to me to have been chiefly directed to the examination of the resistances experienced between the surface of a moving solid and a fluid in contact. Similar experiments have been more recently performed by Meyer.[3] Helmholtz[4] and Pietrowzki have carried on experiments with a notably modified method.

In the two first of these inquiries the experiments were conducted by causing a solid horizontal circular disk immersed in the fluid to undergo periodical oscillations around a vertical axis. In the third, the fluid was included in a solid globe, which was subjected to periodic oscillations. In order to deduce from the facts of observation in these cases any results as to the external or internal resistance of the fluids, elaborate mathematical theories are indispensable. In the latter case especially, the oscillations of the hollow globe produce waves whose motions complicate the phenomena so as to require complex formulæ for their expression.

Among the phenomena in which the internal resistance of fluids may be important, those where liquids are in rotation about an axis seem to be more simple than where they are undergoing large oscillations, and it thus occurred to me that an experimental study of such a motion of fluids might prove fruitful in results. From the nature of fluids it seems likely, whatever precautions we may take, that even the most simple kinds of motion of their particles cannot take place with great rapidity without the production for a time of some kind of oscillation. But the results will probably be less complicated than

[1] The floatation of small solids of greater density than the liquids on the fluid surface shows that the cohesion of the particles of liquid among themselves may be sometimes accompanied by repulsion for solids. I have already brought under the notice of the Academy some remarkable phenomena of this kind, in which the cohesion of the liquid particles for each other was clearly illustrated, as well as their repulsion for the small solid bodies.—"Proceedings of the Royal Irish Academy," vol. i., series ii., p. 153.

[2] "Mémoires de l'Institut National," tom. iii.

[3] Poggendorfs "Annalen," vol. cxiii., p. 55.

[4] "Sitzungsberichte der kais. Academie zu Wien," vol. xl.

VI.—ON EXPERIMENTS TO DETERMINE THE INFLUENCE OF THE MOLECULAR CONDITION OF FLUIDS ON THEIR MOTION WHEN IN ROTATION, AND IN CONTACT WITH SOLIDS. Report, Part I. By HENRY HENNESSY, F.R.S., M.R.I.A., Professor of Applied Mathematics in the Royal College of Science for Ireland.

[Read, February 12, 1877.]

OBSERVATION and experiment have long since completely established that no fluid can be considered as strictly exhibiting the physical properties of the ideal substance commonly defined in almost all treatises and class-books on hydro-mechanics as a perfect fluid.

In a perfect fluid, the particles are supposed to be free to move among each other by the smallest application of force—in other words, they are supposed to be absolutely smooth, and totally destitute of cohesion. With such qualities, their motions would be free from friction amongst themselves, and almost free from friction when in contact with many solid substances. The practical experience of hydraulic engineers has long since clearly shown, that the flow of liquids is accompanied with very notable resistances, which observers attributed to the friction of the liquids against the surfaces of the vessels and pipes in which they were moving. More recently, mathematicians and physical inquirers have been led to recognise a kind of resistance to the motion of fluids depending entirely on the molecular properties of the fluids themselves, and to this kind of resistance the name *internal friction* has been generally applied. If this term is to continue in use, it appears to me that care should be taken to clearly discriminate between this kind of resistance to motion and that of friction, as it is commonly understood between solid bodies. If two perfectly smooth surfaces of solids of the same form and molecular character are in close contact, as, for instance, two sheets of glass, such great resistance to the motion of one upon the other exists, that portions of them are liable to shear away. The resistance to motion in this case is almost entirely due to cohesion. If two dissimilarly constituted substances be moved in contact, experience shows that when they are very smooth the motion meets with little resistance, but when they are rough, the resistance may be very considerable. In the latter case work must be expended in causing the asperities of one surface to surmount or rub away the asperities of the other, and hence, in some languages, friction is spoken of as synonymous with attrition. We possess no evidence for assuming that such conditions exist between the particles of a fluid as to justify us in classifying the internal resistance to its motion as identical with this kind of force. If we reflect on the phenomena of the molecular statics of liquids presented in the well-known phenomena of capillary attraction, and in the admirable researches of Plateau on masses of liquid free from the

termined thickness. At the same time, it follows that this fluid must have properties entirely different from the ideal fluid assumed in Mr. Hopkins' inquiries. I was led to affirm, that the fluid matter of the interior of the earth possessed such an amount of viscidity as to cause it to rotate together with its solid envelope, as if they constituted one continuous mass.

Several years afterwards, by a very simple process of reasoning from physical and mechanical principles, M. Delaunay was led to announce precisely the same conclusions with reference to the motions of the solid and fluid parts of the earth. So remarkable a confirmation of my views created much discussion, and some of those who had adopted the conclusions of Mr. Hopkins seemed to call in question the physical properties of fluids alluded to by M. Delaunay and myself. The properties in question are the outward resistances of fluids to solids in contact with them, and the internal resistances among the fluid particles, when both the fluids and solids are rotating. It is scarcely necessary to say, that the phenomena of fluids in rotation are connected with other physical questions, and they have a most important connexion with questions of the practical application of hydro-mechanics. Hence I may be permitted to hope that the inquiry I have commenced may be attended with some useful result.

The first experiments I tried were similar to those quoted by M. Delaunay, and made, under his direction, by M. Champagneur.

I obtained a small glass globe, which could be more or less filled with liquid by a small opening. A strong silk cord was looped round the region of its equator, and to the opposite sides of this cord a pair of silk threads were attached, which were fastened to a support close to the ceiling of a lofty room. A steady and rapid rotation was communicated to the globe by the torsion of the threads. I half filled the globe with common water, and placed a number of small pieces of paper of the same size on its surface at different distances. Whenever the globe was set in rapid rotation, the pieces of paper were at first left behind, and therefore the water; but when the rotation was long continued, the papers appeared to move at the same rate. If the rotation was slow from the commencement, the papers seemed to move with precisely the same angular velocity as the glass globe. With moderate velocities, if a piece of paper was placed in the centre of the flat surface-hemisphere of water, it required some time to partake of the motion of the vessel, but if placed near the glass it immediately moved.

However instructive these experiments were, they could only be regarded as preliminary inquiries, suggestive of ideas to be tested by more precise methods.

I accordingly, with the assistance of the well-known mechanician and instrument-maker, Mr. Spencer, devised an apparatus which might be employed in the study of phenomena accompanying very slow rotation of fluids or rapid rates of motion. I was particularly desirous of being able to observe the effects of the internal viscidity of liquids by

which the motions of successive strata of the same liquid influence the adjoining strata. On this account I have not employed the arrangement used by Coulomb, and subsequently applied by Meyer, as the direct results which that arrangement gives refer more immediately to the resistance of a solid surface moving against the liquid. Results as to the internal viscidity have subsequently been deduced indirectly from the observations thus made.

As the object of these experiments has been to study the phenomena accompanying the rotation of liquids, a steady rotating motion was indispensable. For this purpose I had a clock specially constructed, which worked by a gearing of toothed wheels, so as to move a vertical axle carrying on it a very strong wooden disk, to which another exactly similar could be fastened by screws. On the latter was fixed a broad socket of hard wood, with a large hollow screw cut deeply within it. The vessels employed were glass, and each carried at bottom a broad solid screw of hard wood firmly attached by cement. In this way the most complete union between the vessel containing the liquid and the rotating support was obtained. The clock was driven by two powerful springs, and was regulated by a pendulum when slow motions were required. A fan with movable pallets was employed as a regulator for rapid motions. The whole was supported by and firmly bolted to a low flat table of wood. The circular disks are furnished with a slotted arm and clamping screw which permits the axis of the vessel containing liquid to be inclined at an angle to the axis of rotation. The vessel which was principally employed is of glass; it has a bell-shaped bottom and cylindrical sides. Around the cylinder a slip of paper, divided into 360 equal parts, was rolled in such a way as to be in the plane of the circle forming the cross section, or in a plane parallel to the surface of the liquid when at rest. In order to observe the relative motions of the liquid and the containing vessel, a strong rectangular frame was fixed to firm supports placed outside the table already mentioned, but not touching it. The cross piece had a slot which permitted a small brass crotchet to be screwed down vertically, after being shifted until it was placed over the centre of the vessel. In this crotchet is a small slit which could be closed by a screw. From the crotchet an indicator was suspended by a fibre of unspun silk, such as is usually employed in galvanometers. The indicator consists of two fine slips of light wood (deal), fastened with strong thread at the ends and half way from the axis. At the axis a piece of very fine platinum wire was looped, and terminated in a small hook, to which the suspending fibre of silk was attached.

The slips of deal were graduated in centimetres, from the centre of suspension outwardly.

Between the two slips of deal two equal and rectangular thin laminas of mica were inserted; these laminas were always placed at equal distances from the point of attachment of the suspending fibre by the aid of the graduation above mentioned. Before making the

experiments, the indicator and its mica plates were always perfectly balanced.

Up to the present, water has been the liquid exclusively employed. I have sometimes used the common water supplied from the waterworks, but recently, distilled water. In making the experiments, great care was necessary in the introduction of the mica plates into the water. If water was a perfect fluid, the introduction of such slender disks would be accompanied by no sensible resistance, but this was so far from being true, that unless both plates were plunged into the liquid at the same time, and to almost equal depths, the equilibrium of the indicator became totally deranged by the difference of the resistance experienced by these disks plunged edgeways. After they had been plunged into the liquid, and allowed to adjust themselves, it was manifest that each disk exercised attraction on the adjacent liquid, from the concave meniscus of liquid heaped up at each side. But this is precisely what is desired, for we wanted an indicator moving as much as possible with the liquid, and immediately partaking of its changes of velocity.

If the air contained in the vessel were absolutely at rest during the rotation, it would resist in a slight degree the motions of the wooden cross-bar and of the pieces of the mica disks above water; but as it is certain that air is endowed with some viscidity, or, as some prefer to call it, internal friction, it must partake in some measure of the motion of the vessel. If it did not, its tendency would manifestly be to keep the indicator in its original place. In this case the moving force acting on the indicator would be that of the strata of liquid pressing against the mica disks, and the resistance, that of the air in which the indicator was partly plunged. From the weight and dimensions of the wooden indicating bar and the mica disks, which I have already given, it is evident that the moment of inertia of the whole is very small, and as yet I have not deemed it necessary to calculate its exact amount. In reducing the results of observation, in order to determine numerical co-efficients for the friction of the fluids against solids, or for internal viscidity, this moment must be estimated.

The apparatus for making the experiments being adapted for working with very slow or rapid motions, it has occurred to me to divide the investigation into two parts. The first refers only to the phenomena of slow rotation. By the adaptation of the pendulum, the vessel containing liquid has been made to revolve at velocities of from about one turn in two hours and a half to one turn in four hours, or six turns in a day.

The method of observation adopted was the following: The vessel was filled with water to a depth of twelve centimetres, which enabled the mica disks to plunge three centimetres into the liquid, leaving one centimetre between the surface of the liquid and the indicating bar. After this had come to perfectly steady condition, the positions of the mica disks were sighted on the graduated circle, and when the sus-

entred, both disks were found at
been previously wound up, it was
was one turn in four hours, it was
disks at short intervals as well as
nd of a few hours. In this way a
ks with reference to the cylinder
the arrangement permitted the
istances from the axis of rotation,
sk was accurately measured before
experiments with very slow rota-
r, and the temperature of the room
gements nearly constantly at about

Slow Rotation.

	A.	B.	V. of R.
disks ation, ..	316°	316°	1 turn in 4 hours.
dis- ..	314	314	
stance ..	316	316	
..	316	316	
..	316	316	
metres nsion,	348½	349	
..	349	349	
metres ..	90	90	
es, ..	106	105	1 turn in 2 hrs. 36 min.
es, ..	86	85½	Same velocity.
es, ..	83	83	

position of index at the beginning, B. at
the containing vessel.

d rotations, the only result which,
bearing upon those obtained from

slow rotation. When the vessel rotated once in thirty, or even in twenty seconds, after an interval of about seven minutes the indicator moved with the same angular velocity as the vessel. When the mica plates had been long immersed in the water, this interval was reduced, showing that the water took time to completely adhere to the mica.

As the radius of the vessel is 132 millimetres, the disks were plunged in water at 42 millimetres from the glass sides in experiments 1, 2, 3, 4, 5, and 9. They were at 72 millimetres in experiments 6, 7, 10, and 11, while in experiment 8 they were at 92 centimetres from the glass. In this way they enable us to observe the relative velocities of the strata situated at very different distances. Yet in all of these observations, from the moment when rotation commenced until its conclusion, the index continued to steadily point to the graduated circle. The adherence of the water to the mica disks was all along distinctly manifest. The water also adhered to the glass at the sides of the vessel, and all through the fluid the adjacent particles were attracted to each other. With slow velocities of rotation, these actions seemed to suffer no disturbance: each successive stratum of water, from the sides of the vessel to the mica plates, revolved with precisely the same angular velocity, and thus the vessel and its contained liquid rotated as one mass.

Besides the experiments recorded in the foregoing Table, I have made several others with slow and quick velocities; the former all lead to the same result as those recorded, and I reserve the discussion of the latter for the second part of my Report. The observations I have already made, and those presented by other inquirers, clearly establish that natural fluids possess internal viscidity to such an extent as to vitally influence conclusions drawn from the mathematical treatment of problems in hydro-mechanics. Capillary phenomena, where the molecular action of solids and liquids at small distances is so strikingly manifested, appear to have led to the notion that, because large and *uncapillary* vessels do not clearly manifest such actions, the motions of liquids within them could be considered as independent of molecular action. But the force of cohesion, from particle to particle, exists throughout the whole of a mass of liquid, no matter how great, and hence its motions are governed by the specific amount of this force. It is singular that the idea of what is called a perfect fluid should be so constantly in the minds of mathematicians who have treated hydro-mechanical questions, when one of the best-known elementary problems implicitly supposes a totally different fluid property. A cylindrical vessel containing liquid is set into very rapid rotation: required the shape of the concave surface of the liquid. The ordinary equations of hydro-dynamics are used for solving the problem, but the hypothesis is made that the angular velocity of each particle of the liquid is the same. This could not be true in a perfect liquid. The cylinder would tend to slip past the particles close to it, and if these acquired any velocity from the roughness of the cylinder, the

adjacent internal strata would remain undisturbed. When the experiment is actually made, the observed and calculated form of surface agree very well. But this arises because the whole fluid possesses internal viscidity whereby each stratum has a grip on that which it encloses, and it cannot rotate without pulling the other.

A mathematician, to whom allusion has been already made, is reported to have declared that the conclusion I put forward, as to the interior fluid of the earth and its containing solid shell rotating as one mass, is "a mechanical impossibility." In making this remark, he had in view the purely ideal substance called a perfect fluid. The experiments I have already made seem to show that, for a natural fluid, the phenomena of its rotation are in harmony with my conclusions, and widely different from those of the ideal substance commonly defined as a fluid in connexion with mathematico-physical theories. In the course of the discussion on the precessional motion of the earth considered as a solid shell enclosing a mass of fluid, it was asserted that the slowness of the precessional motion had nothing to do with the relative velocities of the shell and its contained liquid. The experiments I have made show, on the contrary, that the relative velocities are closely dependent upon the absolute velocity of the solid envelope, and when this moves slowly the liquid is carried along with it as if the whole were one mass.

VII.—On Revival of Manuscripts on Parchment. By R. Angus Smith, Ph. D., F. R. S.

[Read, February 26, 1877.]

Having attended occasionally to the manuscripts sent to me by Dr. Ferguson, although I am not able to say that I have finished my work, it may be well to give the results up to this time. I began with the fullest ignorance, and tried methods long since tried; and I fear that, even now, I am able to speak only of modifications of old plans. Still, as I am not aware that any one has obtained equally good results, I shall venture to send the following with a hope that it may be thought worthy of being laid before the Royal Irish Academy.

I tried, as many people have done, tannin, and find that it acts very differently on different parchments. In one case it was fixed with mastic varnish, and a manuscript of a perfectly illegible character has been thus rendered clear and bright. I am not, however, sure that it is unaltered after a year.

With sulphide of ammonium magnificent dark colours were obtained, but it is not easy to dry the ink before it becomes oxidised, and the dull brown returns. Still I have preserved one manuscript of this kind with mastic varnish, and a part with paraffin, very bright for a year.

I think these processes might be used so that the brightness, if temporary, should give good photographs. They are, however, only imperfect processes. The preservation I found much facilitated by moistening the parchment with water until it was quite soft, and then mounting it on card board. This plan has never, to my knowledge, been adopted with skins, but it seems to answer perfectly. It preserves, at least, one side from the action of the air, and the varnish preserves the other. The back of the paper could also be varnished.

This is a question which requires to be reviewed from many sides, and it is a new one to me, so that I do not say much as yet.

The use of ferro-cyanide of potassium very naturally occurs to a chemist, and it was with this salt I obtained the best results; it was, however, used acid. Hitherto this has not been the case, and I believe a certain destruction of the organic matter of the ink may have taken place without a corresponding deposit of the iron compound. The acid first used was acetic. After having, in the usual way, used solutions which produced results which, to say the least, could not be regarded as final, it was with very great surprise that I saw the whole parchment become white as new, and in all probability much whiter than ever it was before. The dark-brown, dirty, and crumpled parchment, with illegible marks, was like a sheet of white paper with writing perfectly clear and sharp, and when laid on a board, still in a moist state, it was smooth also. This I thought a great triumph, but it

as only superficial, and that the
s longer exposed, but to my grief
began to fade. Seeing this, the
gummed behind, and put on a
phed. The writing was bright
al brilliancy, and as the original
ds, you can judge of the results.
ness has diminished.]
a disappointment; on considering
und by Graham to be soluble, but
agined that it might be so in acetic.
Still we must take the result. To
dful to try another acid, and I took
of the untouched kind to try upon,
which had failed with other pro-
confirmation of the belief that, by
ger, it would take up more of the
trated. One, after eight days' im-
d that point is apparently settled.
as not whitened: true, but it was a
with chemicals previously, that one
neutral solutions with varying re-
ink and the quality of parchment.
ave a belief that the process might
s, but I have no material on which
y old parchments quite useless, and
continuing the trials. This class,
demy, but is found chiefly among
ould not be right to make any ex-
terature of any kind or on very old
dance.
ss is the clearing of the ground. It
enough, but being equalled by the
seen; the absolute whitening of the
f the remaining ink visible, and all
und which will not dissolve the ink.
n with ink prepared with iron salts,
rocess would be perfect, as the ferro-
Where the writing or painting is
e surface will restore the original
characters or lines either for good or
e fullest contrast. I do not know
is country.
the colour; if, for example, there
vater-colour writing or drawing, the
matter of course, be an objection.
e process for paper, because a large
solution not being merely painted

te this in January, 1876, and after a year I
is nothing to alter.]

VIII.—Reports from the Observatory of Trinity College, Dublin.

By Robert S. Ball, LL. D., F. R. S., Andrews Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland.

No. 1.—On the Method of Regulating a Clock intended to show Correct Mean Time.

[Read, February 26, 1877.]

In the following note I describe the method which I have adopted for the regulation of the new mean time clock erected by Messrs. Booth, of Dublin, at the Observatory of Dunsink. This clock controls an electric current, which goes from the Observatory to Dublin, for the purpose of regulating the clock in the Port and Docks Office of Dublin to correct Dublin time.

In the regulation of the clock the object to be attained is to make the clock show correct time directly. In other words, we try to have the error of the clock always small. The method I have employed is the well-known one of applying small correcting weights to the pendulum at the centre of its length. It is possible, however, that the following description of the way to make this correction in a systematic and orderly manner may be of use :—

It was found, by experiment, that a weight of 635 milligrammes, placed upon the "shelf," which is fixed on the pendulum rod at the centre of its length, increased the rate of the clock one second per diem.

I shall suppose that the error of the mean time clock is to be determined every day at mean noon by comparison with the astronomical clock.

Suppose that yesterday at noon the error was E', and that to-day at noon the error is E, the rate of the clock is therefore $E - E'$, and consequently the error at noon to-morrow would be $2E - E'$. If, therefore, we wish to have the clock right at noon to-morrow, a number of weights equivalent to $2E - E'$ must be added to or taken from the shelf at noon to-day. The principle of the correction is that, by comparison of the errors of noon to-day and noon yesterday, we endeavour to make the clock right at noon to-morrow.

In the practical application of this method we may assume that we never have to deal with a clock more than two or three seconds wrong, and under these circumstances the correction may be made with the greatest facility.

We shall assume that half a second is the smallest portion of time of which it is necessary to take cognizance. The following Table will then tell us at once how many weights should be placed on or taken off the shelf:—

k at True Mean Noon to-day.

	0·0	0·5	1·0	1·5	2·0
0	− 2·0	− 3·0	− 4·0	− 5·0	− 6·0
5	− 1·5	− 2·5	− 3·5	− 4·5	− 5·5
·0	− 1·0	− 2·0	− 3·0	− 4·0	− 5·0
·5	− 0·5	− 1·5	− 2·5	− 3·5	− 4·5
·0	+ 0·0	− 1·0	− 2·0	− 3·0	− 4·0
1·5	+ 0·5	− 0·5	− 1·5	− 2·5	− 3·5
2·0	+ 1·0	0·0	− 1·0	− 2·0	− 3·0
2·5	+ 1·5	+ 0·5	− 0·5	− 1·5	− 2·5
3·0	+ 2·0	+ 1·0	0·0	− 1·0	− 2·0

o-day the clock showed 11h. 59m.
0h. 0m. 0·5s., then the table gives
equivalent to 2·5 seconds should be
ock right to-morrow.
ation of this correction fifteen cylin-
ade. These cylinders have weights
, 11, 11·5, 12, 12·5, 13, 13·5, 14,

d by the pendulum bob, in the usual
as possible when the 12·5 second
ylinder are both on the shelf. The
n the case of a considerable change

in the clock-rate, when it may be replaced by the 3 or the 9. The ordinary daily correction is simply made by changing one of the cylinders for another. Thus, to take an example—

Suppose that to-day the clock showed 59 seconds, that yesterday it was correct, then the Table gives + 2. If, then, the cylinder 11·5 were on the pendulum, it should be removed, and 13·5 put on instead. It will, however, occasionally happen that the required correction is beyond the reach of the change which could be effected by one cylinder. It would be so in the instance just given, if the cylinder 13·5 had been on the shelf, instead of 11·5. The correction would then require a cylinder of 15·5. In this case the cylinder 6 is removed, and 9 put on instead, and then the cylinder 12·5 seconds is put on. The second cylinder is thus only required for *secular* corrections, as it were; the ordinary daily correction is effected in a moment by the extremely simple process of changing one cylinder for another.

The cylinders are very readily removed, without deranging the pendulum, and the number appropriate to each cylinder is engraved upon it.

Although this method may seem, in describing it, to be somewhat complicated, yet it works with the greatest facility, and leaves nothing to be desired on the score of precision.

LE OF VARYING ACTION. By PRO-
nicated by DR. BALL.

ril 9, 1877.]

$= H,$

$\int T dt,$

dt

$\dot{\theta} - \frac{dV}{d\theta}\delta\theta\Big) dt + t\delta H$

δH

earing in consequence of Lagrange's
of Motion) $\delta\theta dt$,

$\frac{T}{\dot{\theta}}$, &c.,

s varying action.

X.—Laboratory Notes.[1] By Charles R. C. Tichborne, Ph. D., F. C. S., &c.

No. 6.—On the Formation of Magnetic Oxide by the Dissociation of Ferrous Salts.

[Read, April 23, 1877.]

In the description of a find of magnetic iron ore in Wicklow, which I read before the Royal Geological Society of Ireland, I lately offered some suggestions as regards the processes by which these deposits were formed in such localities; the stratified appearance of the ore, taken in connexion with its associated minerals, at once putting out of question the idea of this magnetite being of igneous origin. There was, however, undoubted evidence of the ore being the result of the oxidation of pyrites into sulphates of the base. Presuming that there is no limestone in this district, it becomes necessary to suppose that the deposition of Fe_3O_4 was determined without the aid of a precipitant. At the time of my reading the Paper to which I have referred, I exhibited a tube, which originally contained a partially oxidized solution of ferrous sulphate (a solution of ferrous sulphate which had been exposed to the air for some twenty-four hours). On submitting this tube, when sealed, to a temperature considerably above the boiling-point of water, magnetic oxide was deposited, apparently in the anhydrus state. On repeating this experiment lately, with definitely oxidized solutions, to my great surprise I got nothing but an anhydrus red precipitate of ferric oxide, perfectly destitute of magnetic properties. I therefore instituted experiments to determine the conditions under which Fe_3O_4, would be deposited.

A mixture was made, which, on precipitation, would give us the molecule FeO, Fe_2, Fe_3, or one in which two-thirds of the solution had been oxidized up to the ferric condition. On heating this solution nothing but ferric oxide was formed.

In one case half the solution had been converted into a ferric, and half left as a ferrous salt. Such a solution contained the elements of an oxide 2FeO, Fe_2, F_3. Only peroxide of iron was obtained in this case also, even after prolonged heating at a very high pressure in sealed tubes. As I thought that the basicity of the solutions might determine the deposition of the magnetic oxide, both of the above solutions were rendered so basic that the slightest application of heat would determine a precipitate on heating. On submitting them to a very high temperature in sealed tubes the deposits were not magnetic, and, therefore, we must come to the conclusion that, owing to the easy dissociation of ferric oxide, that oxide is deposited first, and that the acidity of the solution produced by this act of dissociation is sufficient to keep the ferrous oxide in solution. There is no doubt that a

[1] Continued from vol. ii., series ii., p. 84.

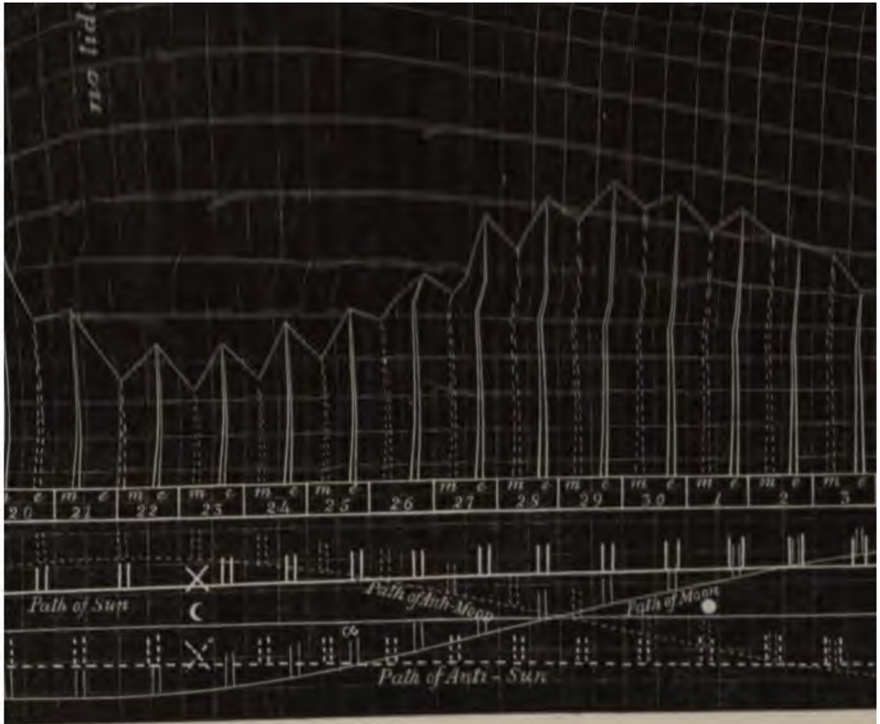
where the dyad iron would be de-
ciently strong to stand the pressure,
resence of alkaline salts, although
ic precipitates, did not in this case
ic oxide.
was allowed to remain exposed
partially oxidized. The resulting
aled tube, and on the application
he magnetic oxide, and apparently
would be deposited from the small
therefore, see that mixtures such
on precipitation by an alkali, or
etic oxide when submitted to the
least they do not do so under the
ing to bear. But we also find that
rous salts, containing 10 to 20 per
sit magnetic oxide, on submitting
ough such a solution on being left
eposit anything but ferric oxide.
precipitated, in time the ferrous
termediate magnetic oxide. On the
100 C., magnetic oxide is deposited
xidized.
origin of this vein of magnetic ore,
action of the air a solution which
quisites—a ferrous sulphate partially
n. Magnetic oxide is found exten-
asses, in all parts of the world. It
and is no doubt frequently formed by
ne earths; but there are certain de-
er do not point to either of those
pplied in this note a description of
gnetite is sometimes formed in the

XI.—Observations on the Phenomena of the Tides as Observed at Fleetwood (Lancashire), with Illustrations from the Tides of Rathmullan (Co. Donegal). By the Rev. James Pearson, M.A., Cantab., Ex-Scholar, Trinity College, Cambridge.

[Read, May 14, 1877.]

Having been for some time engaged in making observations upon the tides at Fleetwood, I wish to place on record some of the theoretical results to which I have been led, as well as to say a few words in reference to a graphical construction which I have found very convenient for illustrating the relation between cause and effect in their production. The most elementary knowledge on the subject teaches us that the elevation of the tides is due not only to the action of the moon and sun on the waters immediately below them, but also that this action is extended directly through the solid body of the earth to the waters on the obverse side of it. The effect may in part be conceived by supposing two moons, one on each side of the earth, the line joining them always passing through its centre, and each attracting, so as to produce on its own side the tide actually exhibited. The first of these being the real moon—the second, or fictitious one, may be called the "anti-moon." In the very same way, we must imagine the tides which are produced by the sun to be of the same twofold character. We are thus introduced to four sets of tides, each, as it will be seen, operating under extremely different circumstances, namely—1st, a *lunar* tide, swelling under the direct action of the moon; 2nd, an *anti-lunar* tide, swelling under the obverse action of the "anti-moon;" 3rd, a *solar* tide, generated under the direct action of the sun; and 4th, an *anti-solar* tide, due to the direct action of the "anti-sun." A little reflection will serve to make it apparent that when the true moon is seen in the northern hemisphere or has *north declination*, the fictitious "anti-moon" or "anti-sun" is over the southern hemisphere, or has *south declination*. More than this, it will be seen that as either of these luminaries advances from *south* to *north* declination, its fictitious antagonist will recede from *north* to *south* declination, and *vice versâ*. But forasmuch as land predominates in the northern, and water in the southern hemisphere, the magnitudes of the tides produced will, from this cause alone, be very different, and when the resulting tides, which are formed of the superimposed tides due to the attractions of the sun and moon, consecutively arrive at our shores, they will display this difference of magnitude very prominently.

Now, to this point I wish to call particular attention. Theoretically, "the action of the moon produces a tidal spheroid; and the protuberances of this spheroid may be considered as composed of two tidal waves—one following the moon, and the other opposite to this. When the sun and moon are not in the equator, one of these may be called the northern, and the other the southern tidal wave. Now, places in the northern hemisphere pass nearer to the pole of the northern tidal wave, and places in the southern hemisphere nearer to the pole of the southern; and hence the tides are alternately greater and


20
21
22
23
24
25
26
27
28
29
30
1
2
3
Path of Sun
Path of Anti-Moon
Path of Moon
Path of Anti-Sun

hour; when the moon's declination is south, this will be the smaller tide." This is precisely what theory advances (see "Whewell's Dynamics," part i., ed. 1832, p. 198); and I am not aware that the true theory, as it is called, which is based on the Harmonic Analysis of the Tides contradicts the more anciently-received one. But, in point of fact, and as the result of observation, the configuration of land and water is such as to cause that tidal wave, whose pole is, or ought to be, in the northern hemisphere, to be *invariably* of *lower* magnitude than that whose pole is in the southern hemisphere; and, as I take it, the simple reason of the contrariety is, that neither moon nor sun can possibly generate a tide in regions where little or no water exists for the purpose.

What observation shows is this—that the *lunar* tide is greater than the *anti-lunar* which follows it, whenever the moon's declination ranges from 20 deg. S., *ascending* to about 15 deg. N. *ascending*; and the *anti-lunar* tide is greater than the *lunar* whenever the moon's declination ranges from 20 deg. N., *descending* to about 15 deg. S., *descending*; the parallax being the same throughout.

A few words must be added in explanation of the accompanying diagram. The figures at the side denote the successive feet as marked on an Admiralty Tide-gauge, whose base is the mean level of low water of ordinary spring tides. The figures at the top of the page point out the days of the month during which the observations were made, and the letters "*m*," "*e*," refer to the morning or evening tide, as the case may be. The figures in the middle of the diagram refer also to the days of the same month, but each of them is put a day and a-half antecedent to those in the top line, because there is that interval from the "transit B" of Sir John Lubbock, during which the tide travels from its cradle in the South Pacific to the Irish Sea. The tides are marked alternately by dotted and by straight lines, the latter indicating what we have called *lunar*, and the former *anti-lunar* tides, and they are laid down to scale, thus showing by the lines joining the summits the course of the curve they form. Within the space at the lower part of the diagram, the moon's path and that of the sun are plotted also to scale, and the dotted lines show those of the "anti-moon" and "anti-sun." A glance from the top to the bottom of the diagram, in the direction of the lines which mark each tide, enables us to complete our description. If we take the morning tide of April 29th, for instance, we can see that it is generated partly by the direct action of the moon with the declination south *ascending* (a circumstance which is favourable to its development), and partly by the direct action of the sun with declination north. The evening tide, on the contrary, is connected with the action of the "anti-moon" in the northern hemisphere, and that of the "anti-sun" in the southern. The former, therefore, is a *lunar* tide compounded with a *solar*, and the latter is an *anti-lunar* tide compounded with an *anti-solar*. The positions of the moon at each quarter are likewise noted, and also at apogee and perigee, and thus it is seen how the sun's angle and the moon's distance separately affect the height of each tide. The method is new, and is very successful.

XII.—REPORT ON THE SOLID AND GASEOUS CONSTITUENTS OF THE MALLOW SPA, IN THE COUNTY OF CORK. By WILLIAM PLUNKETT, Fellow of the Chemical Society, and LANCELOT STUDDERT, LL. D., Ex-Scholar, Trinity College, Dublin.

[Read, June 25, 1877.]

At the suggestion of the Member for the Borough, Mr. John George M'Carthy, M. P., the authors being deputed by the Royal Irish Academy to analyze this mineral water, repaired for the purpose to Mallow, in August last; and the visit was repeated by Mr. Plunkett in the September following. Near the east end of the town, and north of the Blackwater, and at the base of limestone hills sheltering them from the north and east winds, are some warm wells, two of these being in the field adjoining the Spa House, provided by the lord of the manor, Sir Denham Norreys, Bart. This house contains, in the front room, the spring so long used and celebrated.

It is this principal Spa that the authors were instructed to examine; but they thought fit also to determine the gaseous constituents of one of the outside springs, called the Ladies' Well.

The well in the house, besides, supplies the baths in the adjoining room, and its overflow affords enough to the town for domestic purposes. This well is surrounded by a circular margin of stone; it is three feet deep, and two feet and a-half wide.

A tablet there states that "the baths have been found efficacious in the cure of cutaneous diseases, chronic gout, rheumatism, palsy, and stiff joints; (that) they restore the balance of the circulation, allay nervous irritation, and remove pain. The Mallow Spa (it adds) resembles in its properties the hot wells at Clifton, and has been long used for its efficacy in the cure of scrofulous and consumptive diseases."

Doctor Alexander Knox, in his work on "Irish Watering Places," quotes some physicians of Mallow and Cork, much to the same effect.

The principal well in August last showed a temperature of 70·16° F., or 21·2° C., the atmosphere being at 58·1° F., or 14·5° C. Residents of the place agree that this water is warmest in October. the Ladies' Well in August reached 70·8° F., or 21·6° C.; but it is shallower, and more exposed to the sun's heat than the inside spring.

The surface of both wells is overspread with gas bubbles, breaking, and continuously renewed.

"The gas (writes Dr. Knox) was popularly supposed to be principally carbonic acid; but (he adds) if the analysis of Professor Daubeny, instituted on the spot, be correct, it is composed of—nitrogen, 93·5 parts, and oxygen, 6·5 parts" in the hundred.

Analyzing the gases set free at the water's surface, as the authors did, and to which it would seem that Professor Daubeny confined his examination for gases, and also analyzing the gases contained in a measured portion of the water taken from below its surface, which the authors were careful to do, in addition—these double determinations enabled them to go far towards reconciling the apparently conflicting views reported by Dr. Knox.

Moreover, the composition of the gas, as contained in the water, and also the composition of the gas as set free in the spring, agreed so nearly with the composition as calculated in Bunsen's chapter on "Gases absorbed in Mineral Springs," as to be, in his words, a "valuable confirmation of both analyses."

The authors now beg to explain and state the results they obtained for the gaseous and solid constituents of these Mallow waters; the analyses having been conducted in the Laboratory of the Royal College of Science, by the permission of Professor Galloway.

The free gases and the gases absorbed in the water were both examined. The absorbed gases were boiled out from 700 cub. cent. of the water by the method described in Miller's "Elements of Chemistry," part ii., pp. 55, 56; and the analyses were made by the method adopted by Bunsen, as follows:—The gas was measured in an absorption tube, the necessary corrections for temperature, pressure, &c., being made; a bullet of potassic hydrate was then introduced, and time having been allowed for absorption of carbonic acid, the volume was again determined. The remainder was transferred to an eudiometer, mixed with hydrogen and detonating gas, and exploded. The several readings, reduced to 0° C. and one metre pressure, give the necessary data for calculating the amount of the several constituents.

The following are the results:—

PRINCIPAL SPA.—*Free Gases.*

	Volume.	Pressure.	Temp. C.	Vol. at 0° C. and 1 metre pressure.
Gas employed, ...	121·0	·6462	19·4	73·06
After absorption of CO_2, . .	117·0	·6570	19·2	71·82
Gas transferred to eudiometer, .	191·3	·4314	19·2	77·11
After addition of hydrogen, .	219·2	·4604	19·2	94·29
After explosion with detonating gas,	206·4	·4575	21·6	87·51

	P. C.
. . .	1·70
. . .	2·88
. . .	95·42
	100·00

bsorbed Gases.

6 cc. of gases, which is equal to the Litre.

lume.	Pressure.	Temp. C.	Vol. at 0° C. and 1 metre pressure.
32·3	·6719	19·0	83·11
81·0	·6220	18·8	47·14
35·5	·3932	18·8	49·85
83·0	·4401	18·6	75·41
56·0	·4129	18·8	60·27

	P. C.
. . .	43·28
. . .	5·75
. . .	50·97
	100·00

le of the free and absorbed gases in

ng composition :—

	P. C.
. . .	1·49
. . .	2·46
. . .	96·05
	100·00

	P. C.
. . .	32·24
. . .	10·12
. . .	57·64
	100·00

The solid constituents of the principal spa were also determined. They were found to be silica, iron, lime, magnesia, soda (with trace of potash), chlorine, sulphuric acid, and carbonic acid. In 1000 cc. were contained:—

	Grammes.
$Si\,O_3$,	·0152
$Fe_2\,O_3$,	·0005
Ca	·0564
Mg,	·0097
Na,	·0063
SO_4,	·0126
Cl,	·0176

Which may be calculated as being thus combined:—

Silica,	·0152
Ferric Oxide,	·0005
Calcic Sulphate,	·0179
Calcic Carbonate,	·1279
Magnesic Carbonate,	·0246
Magnesic Chloride,	·0105
Sodic Chloride,	·0160
	·2126

The following are the readings for temperature of the waters and of the atmosphere, taken at the two visits mentioned:—

PRINCIPAL SPA.

31st August, 1876.

Air,	14°·5 C.
Water,	21 ·2 ,,

29th September, 1876.

Air,	13°·4 C.
Water,	21 ·5 ,,

LADIES' WELL.

31st August, 1876.

Air,	13°·5 C.
Water,	21 ·6 ,,

29th September, 1876.

Air,	15°·0 C.
Water,	21 ·8 ,,

XIII.—On the Gaseous Constituents of the Vartry and Grand Canal Waters. By Archibald N. M'Alpine, B. Sc., Assoc. R. C. Sc. I.; and Chris. Clarke Hutchinson, Royal Exhibitioner, Royal College of Science.

[Read, June 25, 1877.]

Hitherto, in the examination of waters for domestic purposes, the attention of chemists has been almost entirely confined to the solid bodies they contain in solution, scarcely any attention having been paid to the gaseous substances present.

That gases, like oxygen, when present in considerable quantities, have no effect upon the human system appears unlikely. The Right Hon. Lyon Playfair believes that the medicinal properties of the mineral waters of Buxton are due to the nitrogen they contain. Whether these gases have, or have not, any action, we must leave to medical men to decide; but, at all events, it seems desirable that in the waters examined for drinking purposes the oxygen contained in solution should be estimated, as, from the quantity of this gas present in waters, some clue might be afforded to the state or condition of the organic matters they contain.

With these objects in view, we undertook, at the suggestion of Professor Galloway, the examination and estimation of the gaseous constituents in the Vartry and Grand Canal waters which are supplied to Dublin, and the neighbouring townships.

We conducted the examination and analyses in the following manner:—

A measured volume of the water under investigation was taken; the gases in this volume expelled, collected, and measured; their quantities were determined, and the respective quantities of each present were estimated, by the refined method of gas analysis devised by Professor Bunsen.

For the expulsion and collection of the gases we used the apparatus proposed by Reichardt, and described by Fresenius in the "Zeitschrift für analytische Chemie," vol. xi., p. 271.

Some preliminary experiments were made upon the gases thus obtained, to ascertain the quality of the gaseous mixture. After the removal of the carbonic acid, by means of a potash bullet, and of the oxygen by a coke bullet, saturated with pyro-gallate of potash, the measured gas remaining in the eudiometer was exploded with a measured volume of oxygen, and a detonating mixture of hydrogen and oxygen, obtained by the electrolysis of water. No contraction occurred, other than that due to the detonating gas; the potash bullet was again introduced, and on measuring, the volume remained as before; hence, we inferred, since no carbonic acid had been formed, that carbonic oxide and carburetted hydrogen were absent, and that the gaseous mixture consisted only of carbonic acid, oxygen, and nitrogen.

We now proceeded to the quantitative estimation of the respective gaseous constituents.

The total volume of gas given off by the known volume of water was measured in a calibrated eudiometer, and in common with the other readings reduced to the normal temperature and pressure (0° C. and 760 *m.m.s.* bar. pres.)

A portion of this gas was taken, transferred to another eudiometer, and measured. After absorption of the carbonic acid by a potash bullet, the gas was again read off by the kathetometer, the difference between the readings giving the amount of carbonic acid.

Pure hydrogen evolved by electrolysis was then introduced, and the volume then read off, to ascertain the amount of hydrogen added. The spark given by a Rhumkorff's coil was then passed, and after allowing it to cool, the resulting volume of the exploded gases was read off: one-third of the contraction measures the amount of oxygen present.

The residual hydrogen in the gas having been deducted, the remaining volume gives the amount of nitrogen present. From data thus obtained, were calculated the percentage composition, the absolute volumes in cub. cents. of the gases given off by the measured portion of the water employed; and, from this last, the total volume of the mixture contained in one million litres of water.

We now proceed to give the results of some of our analyses of the Vartry and Canal waters. The samples of the Vartry water were taken from the taps in the Chemical Laboratories of the Royal College of Science, Stephen's-green, Dublin, being collected just before use:—

No. I.—*Taken 25th March*, 1877.

Volume used, ... 2·420 litres.
Temperature of water used, . . . 7° C.

	Volume.	Temperature in 0° C.	Pressure in m. m. s.	Column of Mercury above that in trough in m.m.s.	Corrected Volume at 0°C. and 760 m.m.s. pres.
Total vol. of gas evolved, .	180·347	9·90	740·5	49·9	156·65
After absorption of CO_2, .	169·296	9·45	751·0	52·8	148·41
Gas used, ...	282·362	11·10	752·0	288·1	162·09
After the admission of H, .	412·130	10·80	752·0	166·0	300·63
After explosion, . . .	255·990	10·80	752·0	300·6	143·12

e Composition.

. . . . . .	4·888
. . . . . .	30·806
. . . . . .	64·300
tal, . . .	99·994

osition in Cub. Cents.

. . . . . .	1·934
. . . . . .	12·187
. . . . . .	25·437
otal, . . .	39·558

n 16,346 litres of mixed gases.

18*th June*, 1877.

. . . . .	2·420 litres.
. . . . .	20·25° C.

ume Composition.

. . . .	4·465
. . . .	30·897
. . . .	64·638
Total, . . .	100·000

position in Cub. Cents.

. . . .	1·662
. . . .	11·503
. . . .	24·065
Total, . . .	37·230

ain 15,384 litres of mixed gases.

ı GRAND CANAL.

oss Bridge, 28*th March*, 1877.

. . . . .	2·420 litres.
. . . . .	8° C.

	Volume.	Temperature in o C.	Pressure in m.m.s.	Column of Mercury above that in trough in m.m.s.
Total vol. of gas evolved, .	Not taken	–	–	–
Gas used, ...	315·136	11·2	749·9	256·7
After absorption of CO_2, .	283·370	11·5	750·5	289·0
After admission of H, . .	264·980	11·9	756·5	205·0
After explosion, ...	227·120	12·2	756·5	313·5

Percentage Volume Composition.

Carbonic acid, ...	16·111
Oxygen, ...	21·947
Nitrogen, ...	61·941
Total, . . .	99·999

No. II.—*Taken at Leeson-street Bridge, 11th April,* 187

Volume used, ... 2·420 litres.
Temperature of water, ... 10° C.

	Volume.	Temperature in o C.	Pressure in m.m.s.	Column of Mercury above that in trough in m.m.s.
Total vol. of gas evolved, .	354·320	12·3	756·5	241·8
Gas used, ...	314·718	12·3	756·5	241·8
After absorption of CO_2, .	197·100	10·2	760·0	364·2
After admission of H, .	323·840	10·3	760·0	241·7
After explosion, . . .	214·860	10·4	759·5	315·0

Composition.

. . . . . 51·161
. . . . . 16·260
. . . . . 32·569

al, ... 99·990

ition in Cub. Cents.

. . . . . 26·918
. . . . . 8·558
. . . . . 17·138

al, ... 52·614

21,741 litres of mixed gases.

eet Bridge, 21st June, 1877.

. . . . 2·420 litres.
. . . . 21·8° C.

empera-ture in 0° C.	Pressure in m.m.s.	Column of Mercury above that in trough in m.m.s.	Corrected Volume at 0° C. and 760 m.m.s. pres.
19·9	756·0	302·8	240·810
19·9	756·0	302·8	137·800
19·9	756·0	392·4	057·802
19·7	756·0	240·0	194·850
19·2	750·3	308·8	122·238

me Composition.

. . . . . . 57·8334
. . . . 17·6567
. . . . . . 24·5097

Total. . . 99·9998

Absolute Volume Composition in Cub. Cents.

Carbonic acid,	32·588
Oxygen,	9·949
Nitrogen,	13·812
Total,	56·349

1,000,000 litres of water contain 23,285 litres of mixed gases.

It will be desirable to compare the relative quantities of oxygen and nitrogen obtained in these analyses with the relative proportion of these gases which would be dissolved by a pure water, in contact with air. Bunsen has determined, that in 100 parts of oxygen and nitrogen, dissolved by pure water, the relative proportions are—

Oxygen,	34·91
Nitrogen,	65·09

Comparing the results of our analyses of the Vartry waters with this determination, we find that in 100 parts of dissolved oxygen and nitrogen the following relative proportions obtain :—

No. I.

Oxygen,	32·39
Nitrogen,	67·61

No. II.

Oxygen,	32·34
Nitrogen,	67·66

From this we see that these relative proportions of oxygen and nitrogen pretty closely agree with those which are found in a pure water; but there has been a slight diminution in the proportion of oxygen.

Now, *if* a diminution of oxygen is brought about, in consequence of oxidation of decaying organic matter with which a water comes in contact, then, in the Vartry water, such contamination would seem to have occurred only to a very small extent; and, therefore, on this supposition, it is free from injurious organic constituents.

Making the same comparisons for the Canal waters, we obtain the following :—

No. I.—*From Haroldscross Bridge.*

Oxygen,	26·16
Nitrogen,	73·84

No. II.—*From Leeson-street Bridge.*

Oxygen,	33·368
Nitrogen,	66·632

ggot-street Bridge.

. . . . .	41·873
. . . . .	58·127

expectation; for, since in coming
ty, the amount of contamination
et to find a gradual diminution in
sent. But we really see that the
nitrogen, is increased, the nitrogen
. How this result is to be inter-
ed to say, further than that our
ination increases, the proportion of
he carbonic acid *increases* by about

t of solubility of the nitrogen is
ch a large amount of carbonic acid.
no experimental data.
e in the Chemical Laboratories of
under the direction of Professor

PROCEEDINGS

OF THE

ROYAL IRISH ACADEMY,

VOL. III., SERIES II.

SCIENCE.

DESCRIPTION OF PLATES.

PLATE 2.

Illustrative of a Paper by Mr. John Blackwall and Rev. O. P. Cambridge "On a List of Spiders Captured in the Seychelles Islands by Professor E. Perceval Wright."

Vide Proceedings R. I. Acad., Vol. 3, Ser. 2, p. 1.

Fig. 8.* *Sparassus guttatus*. Bl., ♀. 8*a*, profile, without legs; 8*b*, forepart of cephalo-thorax, showing the relative size and position of the eyes; 8*c*, maxillæ and labium.

9. *Clubiona nigromaculosa*. Bl., ♀. 9*a*, profile, without legs.

10. *Theridion placens*. Bl., ♂. 10*a*, palpus; 10*b*, profile, without legs.

11. *Argyrodes rostrata*. Bl., ♂. 11*a*, profile, without legs; 11*b*, palpus.

12. *Epeira cognata*. Bl., ♂. 12*a*, profile, without legs; 12*b*, palpus; 12*c*, genital aperture of ♀; 12*d*, ditto, from below.

13. *Nephila plumipes*. C. Koch., ♂. 13*a*, palpus.

14. *Tetragnatha minax*. Bl., ♂. 14*a*, one of the falces; 14*b*, forepart of cephalo-thorax, showing the relative size and position of the eyes; 14*c*, palpus.

15. *Tetragnatha Thorellii*. Bl., ♀. 15*a*, profile, without legs; 15*b*, genital aperture.

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* This figure is referred to by mistake, in the description of the Spider, as in Pl. 1.

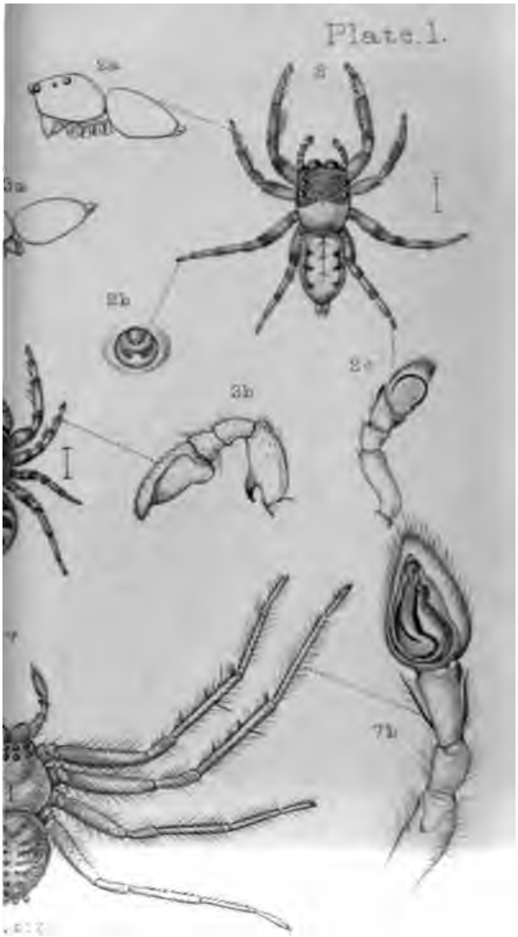


Plate. 1.
2a
2
2b
2c
3b
7b

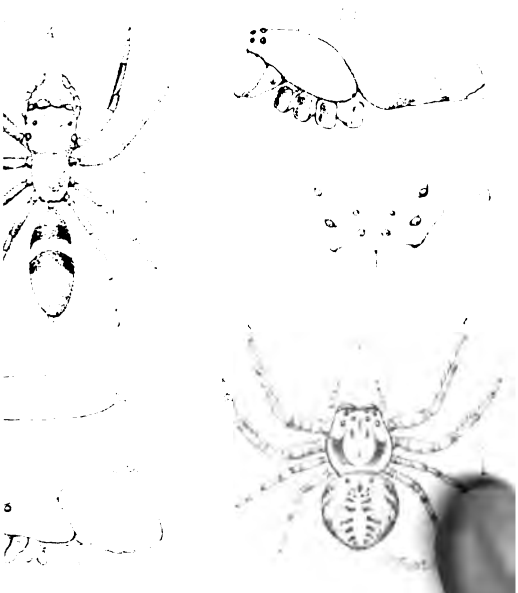
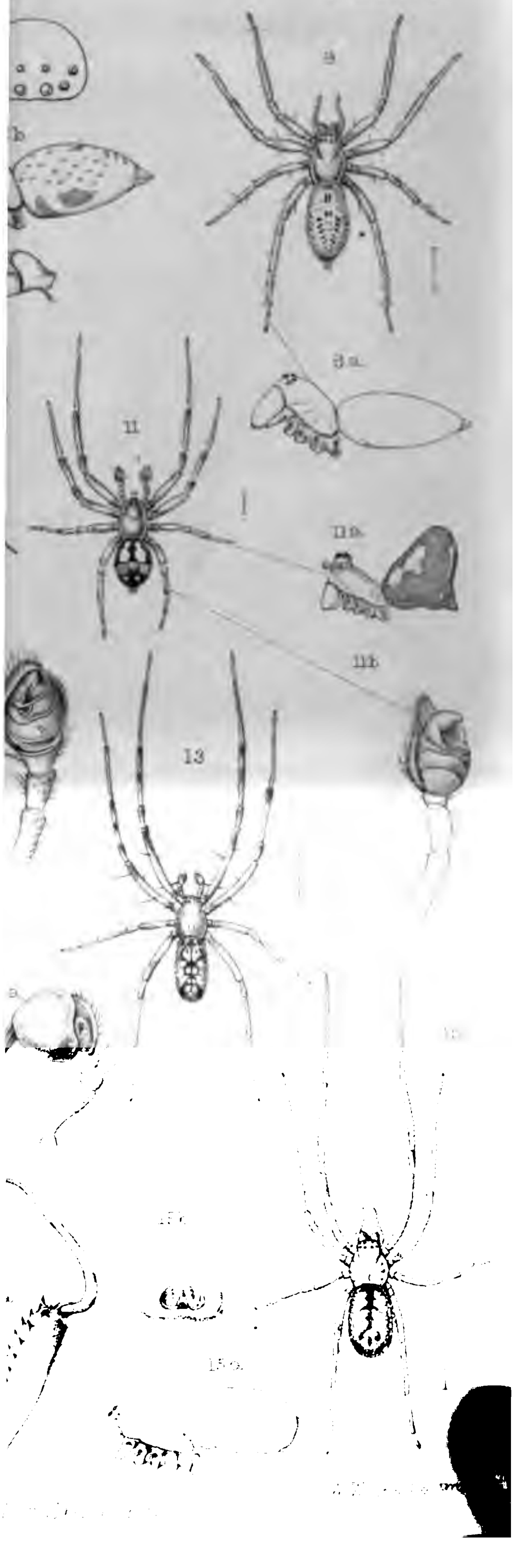


Plate 2.



F FRIDAY THE 6TH APRIL, 1877.
OR O'REILLY.

il 9, 1877.]

ices in the South of Ireland, where isible from Dublin and other locali- onsequently have been of more than ng therefore some notice as a matter

ons under which such phenomena es of individual observers naturally colour, the size, and the direction

re be merely approximated by com- al descriptions. In the case, how- een to explode at the instant of its ed point or line, there remains an he moment can, to a certain extent, when observing the explosion, the uch, by its lower rim, the ridge of road, as I endeavour to show in wing the point where I stood at the pparent angle of the luminous globe r that purpose a pocket sextant and lane of comparison.
cupric chloride when burning, that

me to equal that of the setting sun. to four minutes past 9 o'clock, P. M.,

as about S.W.
movement appeared to be from west tical.
with others communicated to the I find the following additional *data*, respects, with my observations:—

NIGHT METEOR.

THE 'CORK EXAMINER.'

r readers have been discussing the splendid ink it would be worth while if several who ve may discover what its distance from us ppened to see it from first to last. I must e county, exactly in the 8th degree of lon- the heavens exactly about the place of the ly direction, and traversed an arc of about econds. During the last half second it ap- ding, the colour in the meantime having

become more ruddy. About three minutes after its appearance I heard the explosion. As sound travels fourteen miles a minute, the meteor must have been forty-two miles from me when the first explosion occurred; that is, as I calculate, nearly over the Old Head of Kinsale, but rather south of it, and at a height then of thirty miles. While exploding it must have gone twelve miles farther, and its remains may have fallen among the fishing fleet. The meteor appeared to me to have a diameter about one-tenth the apparent diameter of the moon. Hence its real diameter must have been about 200 feet. I calculate its velocity to have been twenty-five miles a second.

"Hoping you may think my observations worth reading,

"I am yours,

"NO ASTRONOMER."

"THE PHENOMENA OF FRIDAY NIGHT.

"'CORK DAILY HERALD.'

"Our Tralee correspondent wrote on Friday night:—

"'A strange meteoric phenomenon was observed here to-night, at a few minutes past nine. Some persons assert that a ball passed along the heavens, and after a second or two it exploded. Immediately the most minute object was observable by the illumination produced. The light only lasted for a few seconds, and it is positively stated that, after the explosion of the ball, fragments of it fell outside the suburbs, and noise resembling thunder was heard after the explosion.'"

"Our Kinsale correspondent writes:—

"'Those "toilers of the deep" who were at sea fishing on Friday night had a good opportunity of observing the meteor. It resembled very closely the full moon, and carried a trail very much like that of a rocket. It shot through the heavens form north-east to south-west, in which point it disappeared. The brilliancy of the blue light which emanated from it, as it sped along the clear sky, made the smallest object on the earth quite visible, and in a few minutes after its disappearance a deep dull sound like distant thunder was heard in a south-westerly direction, which leaves no doubt that it was the noise which followed.'"

"A correspondent writes to us from Kilrush:—

"'An aerolite (*sic*) of remarkable brilliancy and size illuminated the town after nine o'clock last night, and burst noiselessly. It was for more than thirty seconds in view. It was observed by hundreds who were in the streets.'"

The writer, "No Astronomer," gives the size as about one-tenth the apparent diameter of the moon. Refraction would of course make it appear larger to a spectator situated at Dublin, who saw it at the comparatively low angle of 15°.

The height over Cork which he estimates for the globe, at the moment of the explosion, agrees with that resulting from the 15° altitude which I observed.

The direction of movement which he noted S. W. leads to the conclusion that the plane of movement had a westerly inclination.

The Kinsale correspondent gives the size of the meteor as *that of the full moon* (a sufficiently close approximation to mine); the colour he states as *brilliant blue* (a colour hardly distinguishable from brilliant green at night, by many people).

A correspondent writing from Cork gives the colour as *light blue*, and gives as the interval of time between the explosion and the sound *about two minutes*, the time being about 9 o'clock, P. M.

f IRISH FOSSIL MAMMALS. By A.
Professor of Zoology in the Royal

f THE REPORT.)

10, 1877.]

urnished at the request of the Com-
Irish Academy, in consequence of
illustrations than were considered
t of the attendant expense.
ls of Ireland have been variously
st writers on the subject include
ats among the feral lost animals,'
merated whose existence appears
d with typical examples of the
ferred.
nded in this Paper, the only extinct
eland are as follows :—

caballus).
a).
gaceros).
randus).
phas primigenius).
fossilis, vel U. ferox fossilis).

only species hitherto found in fossil
us variabilis), and the Fox (*Canis*
hus).
remains reported to have been dis-
I can make out, to detached bones,
ned as belonging to extinct or fossil

of exuviæ of certain quadrupeds in
s, Ursus spelæus, Ursus maritimus,
to me to rest altogether on unsatis-
its I conclude that my researches into
k of supererogation; for, although
e list of Irish fossil mammals is re-
h England, and in several respects
d, the objects, as far as they extend,
ne exception, also met with in the

f Ireland" (1878). Scott, *Geological Ma-*

superficial deposits of the latter country—a circumstance of some importance when the recent and extinct animals are considered in relation to physical geology and their probable route of migration to Ireland after the Glacial Period.

I shall now proceed to briefly indicate the data on which the foregoing determinations are based.

THE WILD HORSE (*Equus caballus*).

Remains of a small Horse, including many bones, but no teeth, were found in Shandon cave in connexion with the Mammoth, Reindeer, Red Deer, Wolf, Cave Bear (*U. fossilis*, Goldf.), Fox and Hare.[2] Mr. Thompson also refers to teeth from gravel at considerable depths,[3] and many other cases are recorded of the finding of remains in similar deposits. There are also many instances of equine and domesticated animals' remains from caves and prehistoric dwellings, such as crannoges.[4]

The only evidence in connexion with the discovery of remains of *Hippopotamus* in Ireland rests on a single canine tooth said to have been found near Carrickfergus in 1837. I have seen a well executed drawing which is reported to be of this tooth, by the late M. Du Noyer, in the office of the Geological Survey of Ireland. On submitting a copy to Dr. Moore, F. L. S., Naturalist to the Survey, when the discovery was made, he assured me that the above was a true representation of the tooth in question. The specimen, however, is lost, and the circumstances connected with the discovery not being altogether satisfactory, it appears to me prudent to allow the Hippopotamus a place for the present among the doubtful Irish mammals.[5]

THE WILD HOG (*Sus scrofa*).

Remains of the Hog are found in caverns, bogs, and crannoges, &c., in connexion with domestic animals, and there are records of its existence in a feral state in Ireland,[6] but I can find no traces of its contemporaneity with the Mammoth and other pleistocene mammals. Nor is there satisfactory evidence of any feral Bos having been indigenous to Ireland.[7] Historians mention wild cattle, but possibly

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[2] Carte, *Journal Royal Dublin Society*, vol. ii., p. 11. Adams, *Trans. Royal Irish Academy*, vol. xxvi., p. 215.

[3] Owen, *British Fossil Mammals*, p. 391.

[4] Bryce, *Report British Association*, 1834, p. 658. Wilde, *Proceedings of the Royal Irish Academy*, vol. i., p. 420.

[5] Dr. Moore makes a mistake in calling it "an Elephant's tooth" in a letter quoted by Professor Hull, *Journal of the Royal Geological Society, Ireland*, vol. iv., p. 61. The tooth is said to have been found by a son of the well-known Mr. Doran, who collected natural objects, and disposed of them to the officers of the Geological Survey of Ireland.—A. L. A.

[6] Wilde, *Proceedings of the Royal Irish Academy*, vol. vii., p. 208. Giraldus Cambrensis, *Toph. Hibernica*, who says the boars were all deformed, and cowards.

[7] Scowler, *Journal of the Geological Society, Dublin*, vol. i., p. 228.

these were only domesticated animals run wild.[8] Remains of *Bos longifrons* are very plentiful in bogs, river, and lake deposits, along with Sheep, Goats, Horse, Red Deer, Dog, and Fox.[9] It has also been discovered in ancient dwellings, such as crannoges, raths, &c.,[10] and many crania showing their frontals battered in by the poll-axe from these situations, and from other prehistoric dwellings, are preserved in the Museum of Science and Art, Dublin, but I have failed in procuring proofs of its existence as a feral species.

THE IRISH ELK (*Cervus megaceros*).

Enormous quantities of remains of this Deer have been found in sub-turbary deposits, and occasionally in river gravels throughout the island. None of the bones, as far as I have seen, show that either man or beast preyed on the animal. The remarkable incisions frequently observed on its bones from the shell marl are, beyond doubt, as pointed out by Carte, Jukes,[11] and others, the result of friction of opposing surfaces of bones during probable oscillations of the superincumbent bog. This Deer probably existed at the same time with the Cave or Grisly Bear, seeing that remains of the latter have been met with in shell marl under peat of possibly the same age; and there is evidence of its contemporaneity with the Reindeer.[12] The fact that heads of females and hornless heads of Stags are rarely found, whilst cast antlers are not uncommon, may be owing to the absence of the stupendous appendages which would have always greatly interfered with the animal when swimming, as it also assurely placed him at a disadvantage in the forest.

Perhaps, therefore, these accidents occurred at seasons when the sexes were separated, and to all appearances when the horn was in its prime, which would be at the rutting season. A fine head and horns of Reindeer was found by Mr. Moss in lacustrine deposits under bog at Ballybetagh, County Dublin ;[13] and quite recently Mr. Williams, Taxidermist, Dame-street, showed me an antler discovered by him in the above situation. In both cases they were associated with, or near to, enormous quantities of remains of *Cervus megaceros*. Taking the explorations made by Messrs. S. & J. Moss, and the two years' explorations lately carried out by Mr. Williams, it is estimated that, in a space not exceeding one hundred yards, considerably over a hundred crania of this Stag have been exhumed.[14]

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[8] Ball, *Proceedings of the Royal Irish Academy*, vol. ii. 541 ; and Wilde, *Idem*, vol. vii., p. 183.

[9] Du Noyer, *Journal of the Geological Society, Dublin*, vol. i., p. 248 ; and Ball, vol. i., p. 253.

[10] Wilde, *Proceedings of the Royal Irish Academy*, vol. i., p. 426.

[11] *Journal of the Royal Geological Society of Ireland*, vol. i. p. 152 ; and vol. x., p. 127.

[12] Oldham, *Journal of the Geological Society, Dublin*, vol. iii., p. 252.

[13] *Ibid.*

[14] Moss, *Proceedings of the Royal Irish Academy*, second series. vol. ii., p. 517.

the other instances referred to by him in his communication to the British Association now turn out to be doubtful.[27] The above are the only properly authenticated instances of the discovery of Mammoths' remains in Ireland (as far as my investigations extend).

Grisly Bear (*Ursus fossilis, sive ferox*).

The Irish ursine remains as determined by Ball, Carte, and others,[28] are stated to belong to the *Ursus maritimus*, *U. spelæus*, *U. ferox*, and *U. arctos*.

1. As regards *Ursus maritimus*, the data on which the determination was established comprise a humerus, femur, and fibula, besides portion of the atlas and axis; the two latter, strange to say, display complete ankyloses of their articulations. These bones were found in the mud of Loch Gur, in the county of Limerick, and are at present in the Museum of Science and Art.

In comparing the long bones with similar specimens belonging to the Polar Bear, they appear to me to differ from the latter in precisely the same characters as distinguish the bones of the Brown, the Grisly and the extinct cave Bears from the Polar Bear. These points of distinction as regards the latter have been clearly pointed out by Owen,[29] and refer to the (*a*) stoutness of the bones of the Polar species; (*b*) the size and configuration of the internal condyle of the humerus, (*c*) the position of the deltoid ridge; (*d*) the position of the lesser trochanter of the femur. In all these characters the Loch Gur bones disagree with the Polar, and agree with the Brown, Grisly, and Cave Bears, whose long bones are much alike. From the large dimensions of the specimens in question, they seem to belong in all probability to the *Ursus fossilis* of Goldfuss, now generally supposed to be identical with the recent *Ursus ferox*.

The proximal epiphysis of the *humerus* is wanting. The length of the remainder of the bone is 14½ inches. The breadth of the distal articulation is 3·4 inches; maximum width at the distal extremity 5 inches. Unfortunately, the supinator ridge has been destroyed close to its insertion, and prevents me ascertaining the angle made by it with the shaft. The antero posterior diameter at the middle of the deltoid ridge is 2·2 inches; the *femur* is entire, and 18·8 inches in length; the girth midshaft is 5 inches; breadth of the proximal extremity is 5 inches, and the distal 4 inches; the articular surfaces of the latter are 3·7 inches in breadth; the *fibula* is 13 inches in length, and presents the usual variable characters of that bone.

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[27] *Report of the Belfast Meeting of the British Association*, 1875. "On the Post tertiary Fossils of Ireland." By the Rev. Dr. Grainger, D. D.

[28] Ball, *Proceedings of the Royal Irish Academy*, vol. iv., p. 416. Carte, *Journal of the Geological Society, Dublin*, vol. x., p. 114. Scott, *Geological Magazine*, vol. vii., p. 253. Hull, *Journal of the Royal Geological Society, Ireland*, vol. iv., (new series), p. 51.

[29] *British Fossil Mammals*, p. 94.

2. A superb cranium without the mandible is now in the possession of the Earl of Enniskillen, who has kindly furnished me with the following particulars regarding its discovery. It was given to him by Mr. Young, of Monaghan, who told him that he received it from a navvy, and that the latter found it near Ballinamore, in the county of Leitrim, when digging the Shannon and Erne Canal.

The exact stratagraphical position is therefore wanting, but from the light colour of the specimen as compared with the black colouring of the bones from the mud of Loch Gur, it may be presumed that the skull was found in the shell marl, or else the sub-lacustine clay.

The only teeth remaining are the canines and last molar. The latter is 42×22 millimetres, and has the contracted posterior of the Grisly and the *Ursus fossilis* of Goldfuss. The zygomatic arcade is not so broad comparatively, nor are the posterior nasal openings so wide as in *Ursus arctos*. In these two particulars the specimen coincides with crania of the Grisly and *Ursus fossilis*. It differs from *Ursus spelæus* or the gigantic cave Bear in the shape of the last molar and size of the posterior nares, which are apparently narrower in the latter than in any of the foregoing.

The maximum length of the skull is 15 inches, and greatest width 9¼ inches. Mr. J. Allen states that, out of crania of eight recent Grisly Bears examined by him, five were 14½, three over 15, and one was 16 inches in length. The maximum breadth of none of these, however, attains to that of the Leitrim skull, the width of the largest being only 8½ inches.[30]

3. Nearly an entire skeleton was found *in situ* in Shandon cave, in conjunction with the exuviæ of the Mammoth, Hare, Reindeer, Red Deer, Wolf, and Fox. The bones are enumerated by Dr. Carte, F.L.S., in his Report on the Shandon remains, and referred by him to *Ursus spelæus* and *Ursus arctos*.[31] The specimens are in the Museum of Science and Art.

The cranium is in fragments, but several molars and the left ramus of a very aged Bear, besides a fragment of a right ramus, evidently of a larger individual, remain. There is a diseased condition of the left ankle-joint, whereby the distal extremity of the fibula and corresponding surface of the tibia show extensive exostosis, which must have greatly impeded the movements of the animal as far as its predaceous habits were concerned; however, the Grisly Bear of North America, like its Brown congener, can subsist entirely on vegetable food. All the teeth of the above are larger than any of *U. arctus* I have seen.

The fragments of the maxillæ show the sockets of the small premolars as in the Leitrim skull, whilst the 4th p. m. is bitubercular, and

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[30] *Geographical Variation among North American Mammals.*
[31] *Journal of the Royal Dublin Society*, vol. ii., p. 12. Plates xi. and xii.

the ultimate has the contour of that of the Grisly and *Ursus fossilis*. The dimensions of the crown of this tooth are 40 × 24 millimetres, and the penultimate molar 24 × 20 millimetres.

The mandible includes the canine much injured sockets of the 1st p. m.; the sockets of 1st and 3rd, and portion of the 4th p. m.; the sockets of 1st and 2nd, and the ultimate molar are entire, but very much worn; it is rounded behind, as in *Ursus fossilis*, the same part being usually more angular in *Ursus arctos* and the gigantic cave Bear (*Ursus spelæus*).

The dimensions of this ramus, compared with that of a very old individual of *Ursus ferox*, show it to have belonged to a larger individual. There are seemingly no other points of distinction in this specimen, but the fragment of the articular extremity of the other ramus shows the thick incurved angular process apparently more pronounced, as in *Ursus fossilis* and *U. ferox*, than in *U. arctos*.

The other bones referred by Carte to *Ursus arctos* are an atlas, 2 cervical, 2 dorsal, and 2 lumbar vertebræ, with fragments of spinous processes and ribs. None of these appear to me to present morphological characters of importance. As regards dimensions, however, they represent a large Bear, as compared with recent species. The atlas, for example, gives the following:—

Height of the arch inferiorly, ...	$1\cdot\frac{5}{16}$ inches.
Vertebral foramen, ...	1·8 × 1·5 inches.
Anterior articular surface, ...	1·11 × 1· inches.
Posterior articular surface, ...	1·3 × 1· inches.

The long bones agree in their characters and dimensions with the usual specimens of *Ursus fossilis*, but the femur is fully an inch and a-half shorter than the Loch Gur specimen, which doubtless belonged to a very large Bear. As compared with the elements of a skeleton of an aged Grisly in the Museum of the Royal College of Surgeons of England, they indicate a much larger animal, the humerus being one and a-half inches, the femur one inch, and the tibia one and a-quarter inches longer.

These ursine remains from Shandon cave seem to me referrible to one species, and are indistinguishable from similar parts of *Ursus fossilis*, and *Ursus ferox*.

4. Two crania now in the Museum of the Philosophical Society of Leeds are stated to have been found seven feet under ground in a cut-away bog at Ballymahon, on the borders of Longford and Westmeath.[32] The teeth and mandibles are wanting in both. The skulls show the sockets of the first and third premolars. The zygomatic arcade is like the others just described, and the posterior nasal openings are also of the same character. The specimens differ considerably

[32] Denny, *Journal of the Geological and Polytechnic Society of Yorkshire*, April, 1864.

in size, and indicate a female and an old male, as surmised from the sagittal ridge and frontal triangle.[33] The larger, although greatly exceeding the dimensions of any cranium of *Ursus ferox* or *Ursus arctos* with which I have compared it, is three-fourths of an inch shorter than the Leitrim skull; at the same time there can be little doubt but that all the three belong to the same species.

5. A cranium without mandible; No. 28,906 of the Palæontological Collection in the British Museum is stated to have been found "seven feet below the surface in alluvial deposits under bog oak trees at Clonbourne, King's County."[34]

A portion of the left zygoma is lost. The two canines and the fourth premolar and first and second true molars are preserved in the left maxilla, and the ultimate grinder in that of the right side. The molars and alveoli show indications of carious disease. The skull may have belonged to an aged female, or a small male. It is an inch and three quarters shorter than the Leitrim specimen, with which, and the Shandon one, it agrees in the cranial characters and the last molar; whilst the fourth p. m. is also biturbercular, thus correlating all their points of distinction.

6. A cranium, in the Museum of Science and Art, Dublin, was discovered "in cutting away a new channel for the Boyne above Leinster Bridge, in the county of Kildare." Other bones are stated to have been found at the same time, but have not, however, been preserved.[35] The skull is dark, and, like the bones from the deposits of Loch Gur, contrasts in that respect with the other skulls from the shell marl and clays. Moreover, this skull is much smaller than any of the foregoing, being two and a-half inches shorter than the Leinster cranium. The coronal ridges are not well develoved, and although the sutures are closed, it evidently belonged to a female or adolescent male. The zygomata, incisors, ultimate true molar, together with the first and third of the right maxillæ, are wanting. The alveolus of the first premolar of the right side is completely obliterated, which is not by any means common unless in the gigantic cave Bear, where it is very generally absent.

The fourth premolar and successional molars are present in the right maxilla, and are not much worn. The last molar has the round posterior portion of the crown slightly contracted, with the three cusps on the outer side of the grinding surface, and is much of the same size as in *Ursus fossilis* and *U. ferox*. It is 34 × 20 millimetres. The contour of the zygoma cannot be ascertained, but the posterior nares are wider than usually noticed in *Ursus ferox*. This cranium

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[33] Mr. Denny, from such obvious discrepancies in the cranial ridges, has described them as specific distinctions, whereas they are mere conditions relating to age and sex.

[34] *Catalogue of the Industrial Exhibition of Dublin*, 1853, p. 152.

[35] Wilde, *Proceedings of the Royal Irish Academy*, vol. v., p. 53, *Appendix*, and vol. vii., p. 192; fig. 1.

has been supposed, on account of its small size and dark colour, to have belonged to the *Ursus arctos;* but although smaller by a good deal than the usual cranium of *Ursus fossilis*, it is equal to that of a Grisly Bear, with which it is closely related in having a tricuspidated last molar.

Mr. Busk, F.R.S., referring to several of these crania in his Report on Buxham cave,[36] unhesitatingly places them with *Ursus fossilis sive Ursus ferox fossilis*, and, as far as I have seen, this is the only form represented by the ursine remains hitherto reported from Ireland. The absence of the Brown Bear, or rather of any cogent evidence of the animal either in a fossil state or historically,[37] is noteworthy as compared with the Brown Bear of Scotland and England. But the relationship between *Ursus ferox* and *Ursus arctos* is very close, not only as regards the fossil but also the recent individuals; so much is this the case, that individuals are indistinguishable by external appearances; and as to their dentitions and osteologies, Mr. Busk shows in his very exhaustive account of the Quaternary fauna of Gibraltar,[38] that the ursine remains from Genista cave indicate that they belonged to a Bear "closely related to *Ursus fossilis sive priscus*, or to a form intermediate between it and the *Ursus arctos var. isabellinus*." Indeed no recent carnivore presents more well-marked varieties than the *Ursus arctos*, as differentiated by external colouring, but the isabelline variety of the Himalayas and Turkestan presents a more warty or porcine-like grinding surface of its molars than is ordinarly observed in the species elsewhere. This condition, I have no doubt, from extensive observations of the above variety in its native haunts, is the result of altered conditions of life; inasmuch as the isabelline Bear, unable to capture the agile animals of the Alpine regions it frequents, is driven to subsist almost entirely on roots of plants, and other vegetable food; hence its timidity as compared with the *Ursus ferox*, which still continues to follow the Bison.

How far the wider posterior nares in the Brown Bear, as compared with *Ursus ferox*, and in particular *Ursus spelæus*, may be the result of natural selection, giving a more extended surface for smell, on which the recent Brown Bear depends almost entirely in discovering the presence of his most deadly enemy, and also in supplying a condition favourable for free respiratory action, under the trying circumstances in which the animal is now placed, is a point on which it seems to me one is free to speculate, when we come to consider the severe struggles for existence to which an omnivorous plantigrade like the tardy Bear has been subject to throughout the Tertiary Epoch.

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[36] *Philosophical Transactions*, vol. clxiii., p. 632.

[37] Bede, *obiit* 735, A. D., asserts that the Wolf and Fox were the sole large carnivora of Ireland. St. Donatus, *obiit* 840, A.D., writes "*ursorum rabies nulla est ibi*;" and Sylvester Jerald Barry does not mention the animal.

[38] *Transactions of the Zoological Society, London*, vol. x., p. 65. See also Allen, *Op. cit.*, p. 334.

THE WOLF (*Canis lupus*).

The Wolf is included among the Irish pleistocene Mammals, as shown by the discovery of bones and teeth in Shandon cave along with the Mammoth, Reindeer, Horse, &c.[39] It was only exterminated at the beginning of last century.[40]

Vulpine remains identical with the recent Fox, *C. vulpes*, were found in Shandon cave with the foregoing and the other extinct mammals already enumerated. I found its teeth and bones also in the more superficial deposits, accompanied by bones of Horse, Reindeer, Red Deer, Hare, &c.

ALPINE HARE (*Lepus variabilis*).

A cranium and several bones of a Hare found in Shandon cave, along with vertebræ and molars of the mammoth, show shorter and stouter shafts of the long bones than appear in the fossil Hares from Kent's Hole, and the recent *Lepus timidus*, which is not known to have been indigenous to Ireland. The probability therefore is that, as the same parts of *Lepus variabilis* display similar characters, and the so-called variety *L. Hibernicus* being the Hare of the island, it has appeared to me that the above might belong to the latter.[41] Traces of the teeth of a Rodent of about the dimensions of a Rat were evident on the Mammoth, and other remains from the cave of Shandon, but none of its remains were found.

A comparison of the Irish and Scotch lists of Post-tertiary mammals shows an absence in Ireland of the Elk, Roebuck, Urus, Beaver, Hare, Water Rat, Red Field Vale, Meadow Mouse, Common Shrew, and Mole.

The Bear of Scotland was presumably, and very probably, the *Ursus arctos*, but none of its remains have been preserved; considering, however, its affinities to *Ursus fossilis*, the absence of the Brown Bear from the Irish fauna is not very important. The Wild Cat, Weazel, and Foumart are also absentees.

As compared with England and Wales, there is a marked absence in both Scotland and Ireland of the two species of Rhinoceros, Hippopotamus (?), Bison, Musk Sheep, and ancient Elephant, pouched Marmot Pika, Lemmings, Dormouse, Scandinavian Vole, Champagnol, The Lion, Sabre-toothed Lion, Panther, Lynx, Caffre Cat, Arctic Fox, Spotted Hyæna, Glutton, and gigantic cave Bear.

It is important to observe that all the living and extinct mammals of Ireland, with the exception of the *Ursus fossilis*, have been recorded also from Scotland; that is to say, there is no mammal, recent or lost, in the island which is not also found in Scotland.

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[39] Author, *Transactions of the Royal Irish Academy*, vol. xxvi., p. 227.

[40] The Wolf was exterminated in 1710, and was very plentiful in 1652; Smith's *History of Kerry*, 173; Champion, Lombard, &c., &c.

[41] Adams, *Transactions of the Royal Irish Academy*, vol. xxvi., p. 228.

To the absence of the Lions, Panther, Spotted Hyæna, and gigantic cave Bear may be owing the seeming prevalence of the Irish Elk in Ireland; but at the same time it is important to bear in mind that the quantities of remains of this ruminant have been obtained under conditions clearly indicating that the individuals had been drowned in lakes which, during the Post-glacial Period, must have been extremely plentiful throughout Ireland, whose physical aspect would have been then inimical to such as the Marmot, Lemmings, Pika, Bison, and Urus, which delight in broad pastures and grassy uplands.

But the probability is, that the migration came from Scotland, and that there was a land communication between the two countries at the close of the Glacial Period, by which the greater portion of the mammals that had found their ways to Scotland crossed to Ireland. Irrespective of the soundings between northern Ireland and south-western Scotland, there is evidence of the remains of the Mammoth, Reindeer, Irish Elk, and Horse having been found in similar deposits in Ayrshire, Renfrewshire, Lanarkshire, and bed of the Clyde. The Irish Elk has been found in the Isle of Man, and a jaw and teeth of the Mammoth in the harbour of Holyhead, whilst on the other hand the caves of Glamorganshire have produced nearly all the English Post-glacial mammals not met with in Scotland or Ireland; consequently, if an uninterrupted land communication existed between south-western England and Wales, and Ireland, at the close of the Glacial Period, we should expect to find remains of these characteristic mammals, which is not the case. Again, the animals we do find are, for the most part, vagrant species such as the Horse, Mammoth, Reindeer, Red deer, Bear, Wolf, and Fox,[42] so that the severance took place before the slow travelling Mole Beaver, the forest-haunting Elk and Roebuck had time to arrive. It has been suggested by my friend Professor Hull, F. R. S.,[43] that there may have been a narrow channel between the islands, and that the mammals swam across, or arrived on ice-rafts: but looking over the list of the fauna of Ireland, it seems to me that nothing short of a direct land union will meet the requirements of the case.

Excluding the Cetacea, marine Carnivora, and the Chieroptera, it will be found that out of twenty-eight recent species affecting England and Wales, twenty-six are indigenous to Scotland, and fifteen to Ireland; whereas of thirty-two extinct species hitherto recorded for England and Wales, ten have been found in Scotland, and only seven in Ireland.

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[42] According to Thompson, out of eleven British Amphibians and Reptiles, only five have been found in Ireland, including the Agile Lizard, two Tritons, and two Frogs, and about the same proportion characterises the lower groups, to wit, the air-breathing Mollusks and land Arthropoda.

[43] "Presidental Address," *Journal, Royal Geological Society of Ireland*, 1875, vol. iv., (N. S.), p. 52.

—ON THE FORMATION AND COMPOSITION OF SOME COMPLEX OXIDES COBALT AND NICKEL. By THOMAS BAYLEY, Associate Royal llege of Science, Ireland.

[Read, June 25, 1877.]

preparing standard solutions of nickel and cobalt salts for the es of a research on the colorimetric relations and on the colori- estimation of those metals, I was endeavouring to use a modifi- of the method of estimating nickel and cobalt, indicated by [1], depending for their determination on the iodine liberated by her oxides of these metals in contact with hydrochloric acid, tassium iodide. The method was as follows:—The solution of kel or cobalt salt was made alkaline by soda and then mixed xcess of sodic hypochlorite obtained by the action of cold sodic carbonate on fresh bleaching powder.

er allowing the slightly warm solution of nickel or cobalt to some time, so as to ensure complete oxidation, the temperature ised until brisk effervescence ensued, and the solution allowed ain at that temperature until the excess of hypochlorite was posed. When the evolution of oxygen had ceased, the liquid iled for about half an hour. I found that by this process it is destroy all matter, except the oxide, capable of liberating on treatment with potassic iodide and hydrochloric acid. The n having been cooled, it was mixed with excess of potassic and then with enough hydrochloric acid to dissolve the ded oxide. The liberated iodine was then estimated by a rd solution of sodic thiosulphate ($Na_2\,S_2\,O_3$).

the first experiments I used a standard solution of nitrate el, and calculated the nickel from the iodine set free according following equation:—

$$Ni_2\,O_3 + 6HCl = 2Ni\,Cl_2 + Cl_2 + 3H_2O.$$

he results were not satisfactory, as will be seen from the following :—

Nickel used.	Nickel found.
grams.	grams.
·1570	·1437
·1570	·1580
·1570	·1465
·1570	·1568
·1570	·1639
·1570	·1541

[1] Ann. Ch. Pharm. lxxxvi. 265.

Besides these analyses there were several which yielded a far less quantity of nickel. The same method was then applied to cobalt, with this difference, that the solution was boiled only for a few minutes, as I found that length of time sufficient for the decomposition of the last traces of hypochlorite. The amounts of iodine liberated were much greater than would be due to the oxide $Co_2 O_3$, while they agreed perfectly with an oxide $Co_3 O_5$, thus:—

Cobalt used.	Iodine liberated.	Theory of Iodine for Co_3O_5.
grams.	grams.	grams.
·1865	·5338	·5343
·1865	·5380	·5343
·1865	·5328	·5343

I now repeated the experiments with nickel, taking care to boil the liquid only a minute or two. In one or two instances it was not boiled, but the precipitate filtered off and washed. The results were as follows:—

Nickel used.	Iodine liberated.	Theory of Iodine for Ni_3O_5.
grams.	grams.	grams.
·1570	·4428	·4521
·0785	·2263	·2260
·1835	·5318	·5284
·1570	·4490	·4521

With a mixture of ·1863 gram. cobalt, and ·1835 gram. nickel:—

Iodine found.	Theory for Iodine due to $Ni_3 O_5$ & $Co_3 O_5$.
grams.	grams.
1·0532	1·0627

In the last case the oxides were not boiled, but the solution was allowed to stand over the steam bath for a few hours.

With solutions of known quantities of nickel, I now made the following experiments. The solution with the suspended oxide was boiled for some hours.

Nickel used.	Iodine found.	Theory of Iodine. for Ni_3O_4.
grams.	grams.	grams.
·1835	·2009	·2642
·1835	·1812	·2642
·1835	·2321	·2642
.1835	·3310	·2642
·1835	·2830	·2642
·1835	·3765	·2642
·1835	·1069	·2642

In the last experiment the solution was boiled for a few days.

A quantity of cobalt nitrate was now mixed with soda and sodic hypochlorite, and allowed to stand in a warm place until effervescence had ceased. The precipitated oxide of cobalt was then well washed with warm water and dried, till constant, under the air pump, over strong sulphuric acid.

A sample of this oxide was then submitted in succession to various temperatures. The results were as follows:—

	grams.		grams.
Oxide taken, ...	·9278	(Co_3O_5, $4H_2O$).	
Oxide dried at 100° C, .	·8760	Theory for Co_3O_5, $3H_2O$, .	·8770
,, ,, ,, 138° C, .	·8223	,, ,, Co_3O_5, $2H_2O$, .	·8263
,, ,, ,, 310° C, .	·7548	,, ,, Co_3O_5, H_2O, .	·7756

After this experiment there was an appearance of change on the surface of the oxide.

	grams.		grams.
Oxide after ignition to redness, .	·6840	Theory for Co_3O_4, .	·6798.

Another portion of the same sample:—

	grams.		grams.
Oxide dried at 100° C, .	·4070	(= Co_3O_5, $3H_2O$).	
Oxide after ignition to redness, .	·3125	Theory for Co_3O_4,	·3154.

Another sample prepared in the same way, but left longer over the air pump:

	grams.
Oxide taken dried over H_2SO_4 .	·7083.

The oxide was now heated to low redness in a tube in a current of

and the water given off collected in a tube filled with ide. The oxide was afterwards ignited to bright redness

	grams.
alcium chloride tube, .	65·3250
alc. chl. tube + water, .	65·4680
	·1430 = OH_2

	grams.
Oxide after ignition in the tube, .	·5493
Oxide after ignition in air, .	·5293

of this experiment are compared below with the theory). For a reason which will be seen further on, I have theory for Co_2O_3, $3H_2O$.

Theory for Co_3O_5, $4H_2O$.		Found.	Error.
	grams.	grams.	grams.
$4H_2O$, .	·1549	·1428 .	− ·012
Co_3O_5, .	·5534	·5493 .	− ·004
Co_3O_4, .	·5190	·5293 .	+ ·013

Percentages.

	Co_3O_5, $4H_2O$.	Found.	Co_2O_3, $3H_2O$
OH_2, .	21·86	20·16	24·54
Co_3O_4, .	73·27	74·68	73·05
	95·13	94·84	97·59

Winkelbleck obtained an oxide in the same way as I prepared my samples, only that he boiled his with strong potash before washing it. He dried his oxide over strong sulphuric acid. According to him, the formula is Co_2O_3, $3H_2O$. His results were as follows:—

	Per Cent. (1)	Per Cent. (2)	Per cent. Theory.
2Co, . .	53·83	53·93	53·64
3O, . .	21·62	21·46	21·82
$3H_2O$, . .	24·26	24·61	24·54

The question, which is the true formula of the oxide I obtained, is determined by the amount of iodine liberated by the oxide on treatment with potassic iodide and hydrochloric acid. According to the formula Co_2O_3 3 H_2O, there should be liberated ·402 gram by ·1865 gram of cobalt; according to the formula Co_3O_5, 4 H_2O, ·5343 grams should be liberated. I found in three experiments ·5338, ·5380, and ·5328.

When the oxide Co_3O_5, 4 H_2O, obtained as described above, is boiled for an hour or two in the solution in which it is precipitated, and the amount of iodine liberated then estimated, the result points to the formation of the oxide $Co_{12}O_{19}$ intermediate between Co_3O_5 and Co_2O_3.

Co. taken.	Theory of I. for Co_3O_5	Theory of I. for Co_2O_3		Found.
gram.	gram.	gram.		gram.
·1865	·5343	·4007	(1)	·453
	$\underbrace{\qquad\qquad}$ Mean.		(2)	·463
	·4676		(3)	·462

	Theory for $Co_{12}O_{19}$ Iod.	Found. gram.
·0620	·1566 gram.	·1556

In the last experiment a fresh solution of cobalt, and a fresh solution of potassium bichromate (to standardise the thiosulphate), were used.

A quantity of the oxide of cobalt prepared by precipitating with potash and sodic hypochlorite, and *boiling for some hours*, then washing and drying over sulphuric acid *in vacuo*, was submitted to a current of air at a low red heat, and the water collected and weighed in a calcium chloride tube. The oxide was afterwards ignited to bright redness in air.

	grams.
Oxide dried over H_2SO_4,	·7455
Oxide after ignition in tube ($Co_{12}O_{19}$),	·6255
Oxide after ignition in air (Co_3O_4),	·5975
Calcium chloride tube + OH_2,	65·5900
Calcium chloride tube,	65·4645
	·1255 = OH_2

	Theory for $Co_{12}O_{19}$, 11 H_2O. grams.	Found. grams.
OH_2	·1218	·1255
$Co_{12}O_{19}$	·6236	·6255
Co_3O_4	·5940	·5975

Percentage.

	Theory for $Co_{12}O_{19}$, 11 H_2O	Found.
OH_2	16·34	16·83
$Co_{12}O_{19}$	83·65	83·90

On attempting to prepare Ni_3O_5 in the dry state by precipitating, washing, and drying *in vacuo*, I found that the moist precipitate gave off oxygen as soon as the liquid in which it was precipitated was removed. The moist precipitate was allowed to stand some days, and then left over the air pump for about a week, in order to allow time for this change to be complete. Owing to some interruption, I have as yet had time to prepare only one sample by this means. The results of the analysis agree closely with the formula Ni_8O_{11}, 9 H_2O, one-ninth of the water being lost at 100°C.

	Oxide taken. grams.	Theory of Iodine for Ni_8O_{11}, 9 H_2O. grams.	Found. grams.
Dried over H^2SO_4	·1705	·1607	·1661
,, ,, ,,	·2012	·1896	·1895
,, ,, ,,	·2375	·2238	·2243

	Oxide taken. grams.	Theory of Iodine for Ni_8O_{11}, 9 H_2O. grams.	Found. grams.
Dried at 100°C.	·2080	·2005	·2026

The water in this oxide was determined by igniting the oxide in a platinum boat in a combustion tube, and weighing the water lost by means of a calcium chloride tube.

Oxide taken. grams.	Theory for Ni_8O_{11}, 9 H_2O.	Found. grams.
·8723	·1748 grm. OH_2	·1775

Per Cent.

OH_2	20·039	20·34

Per Cent.

	Theory for Ni_8O_{11}, 9 H_2O. grams.		Found. grams.
NiO	74·02	(1)	74·15
		(2)	74·29

Summary.

Under the influence of the hypochlorite solution nickel and cobalt form the oxides Ni_3O_5 and Co_3O_5. On boiling the liquid containing Co_3O_5 it loses oxygen, and passes to the form $Co_{12}O_{19}$, intermediate between Co_2O_3 and Co_3O_5. Under similar circumstances, Ni_3O_5 appears to decompose without forming stable lower oxides, although it is probable from the results that the formation of Ni_2O_3 is a stage in the process. The oxides Co_3O_5 and $Co_{12}O_{19}$ appear to be stable at a low red heat; they are distinguished from Co_3O_4 by a slight difference of colour. Co_3O_5 has the following hydrates:—

Co_3O_5, 4 H_2O (dried over H_2SO_4),
Co_3O_5, 3 H_2O (dried at 100°C),
Co_3O_5, 2 H_2O (dried at 138°C),

and probably,

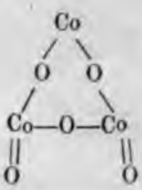
Co_3O_5, H_2O (dried at 300°C).

Ni_3O_5 decomposes while still moist when its precipitating liquid is removed by washing. In the one experiment which was made, the resulting dried compound agreed closely with the formula Ni_8O_{11}, 9 H_2O. I have found that, when Co_3O_5, 4 H_2O is treated with cold dilute nitric acid, part is dissolved with evolution of oxygen, and that part remains insoluble. I hope, in a future Paper, to give the results of some similar experiments undertaken for the purpose of determining the proximate constitution of these oxides.

It may at first sight appear that the formula $Co_{12}O_{19}$ is inadmissible on account of its complexity, but as the iodine method clearly shows that the oxide is exactly intermediate between Co_3O_5 and Co_2O_3, and as the formula $Co_{12}O_{19}$ is the simplest formula for such an oxide, it would seem that we must accept it, especially when we consider the tendency of cobalt to form compounds vieing in complexity with many of the products of organic chemistry. It may be that the application of the iodine method to the examination of the oxides of other metals would lead to the acceptance of formulæ more complex than those now admitted. The two oxides of cobalt described in this Paper, and indeed other oxides of cobalt, may be represented graphically by rings some-

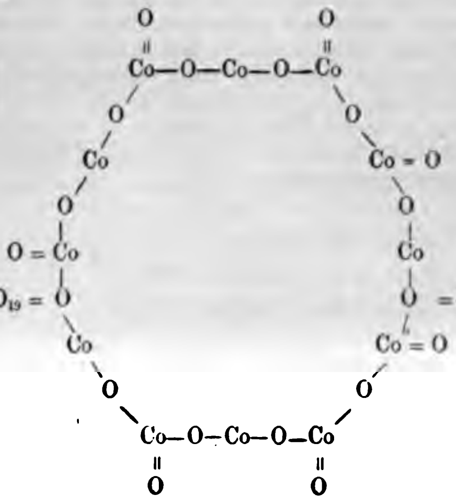
us to the well-known benzine ring of the aromatic car-
s. Thus:—

$Co_3O_5 =$



$= Co''O,\ 2\ Co^{IV}O_2$

$Co_{12}O_{19} =$



$= 5\ Co''O,\ 7\ Co^{IV}O_2$

This investigation was conducted in the Chemical Laboratory of the Royal College of Science, Ireland.

XVIII.—ON THE ALBUMINOID MATTERS, ALCOHOL, AND PHOSPHATES, IN THE BURTON ALES AND IN DUBLIN PORTER. By REGINALD LAWRENCE and C. W. REILLY, Associates of the Royal College of Science.

[Read, June 25, 1877.]

THE two kinds of malt liquor, Burton Ale and Dublin Porter, are so largely consumed at the present time, that it appeared to us desirable to have the three classes of Dublin porter, as manufactured by Messrs. Arthur Guinness & Son, and the Burton ales, manufactured by the two most noted brewers, Messrs. Bass and Allsopp, examined under the same conditions.

The samples of the Burton ales examined we obtained from Messrs. Falkner, of this city, and we are greatly indebted to the kindness of Messrs. Arthur Guinness & Son for supplying us with the samples of porter we required for our investigation.

We confined our examination to the estimation of the principal constituents:—the phosphoric acid existing in the form of phosphates, the albuminoid matter and alcohol, together with the acetic acid, the total amount of solid matter, and the specific gravities of the different samples.

The phosphoric acid was determined in the ash by a standard solution of acetate of uranium; in the estimation of the albuminous matter, acetic acid, alcohol, and total solids, we followed the plans given by Messrs. Jackson and Wonfor.[1]

We may add that the quantity of albuminous matter was determined by first finding the amount of nitrogen by Will and Varrentrapp's method, and then taking 15·92 parts of nitrogen as equal to 100 parts of albumen.

Our investigations show that some of the principal elements of nutrition are present in larger quantities in the Foreign and ordinary Dublin Double stout than in the Burton ales.

This investigation was carried on in the Laboratory of the College of Science, under the direction of Professor Galloway.

The following are the quantities of the substances we estimated, expressed in grains per gallon :—

[1] Messrs. Jackson and Wonfor "On the Composition of the Dublin Porter."—*Journal of the Royal Dublin Society*, vol. iii., page 163.

	Bass's Ale.	Allsopp's Ale.			
ALBUMINOID MATTER,	1st Estimation :— 333·2404 2nd Estimation :— 340·5217 Mean = 336·8810	327·1731 316·7365 321·9548	574·0000 549·6250 561·8125	435·303 422·112 428·708	[illegible] 307·790
ACETIC ACID, . . .	1st Estimation :— 95·9280 2nd Estimation :— 96·1310 Mean = 96·0295	168·210 167·90 167·05	261·786 255·7058 258·7409	139·300 147·000 143·150	160·580 160·090 160·335
ALCOHOL, ...	4383·4000 4365·9000 4374·6509	4478·5125 4443·8625 4461·1875	5128·2000	4643·100	3534·3000
P_2O_5, ...	19·425	18·375	123·110	111·088	85·600 79·829 82·715
TOTAL SOLIDS, . .	4884	3110	4374	5068	3838·5
SPECIFIC GRAVITIES,	1·0138	1·0144	1·01157	—	1·12438

XIX.—COMPUTATION OF TIDES AT FLEETWOOD.—RESULTS OF THEORY AND OBSERVATION. By JAMES PEARSON, M. A., Ex-Scholar (15th Wrangler), Trinity College, Cambridge.

[Read, November 12, 1877.]

IN resuming the consideration of the subject of the tides, it is not my intention to enter at any greater length into the theory which has produced results so closely in accordance with observation: it is sufficient for me to make some remarks on the principal cause of such discrepancies as are found to arise where tables have been used which are based upon that theory—and amongst these disturbing influences, the pressure of the atmosphere ranks foremost. A very simple process may be employed to establish this. It is found that, in the same month, but in different years, the same, or nearly the same, constituents have to be employed in computing a tide; and as like causes produce like effects in nature, the resulting tide ought to be the same in both cases. But it is not so, and the variation is found to depend on the height of the mercury in the barometer, or, more correctly, on the magnitude and direction of the gradients indicated in the weather reports issued in the newspapers. Another disturbing element is that which depends on the suddenness with which the pressure shifts its direction. Thus, a south-east wind rapidly changing into a south-west wind causes an unusual elevation of the level of the Irish Sea. Two examples may serve by way of illustration. In the first case there are exhibited two tides which have very nearly the same constituents, and which, in consequence of the atmospheric conditions being the same, give results both agreeing with observation. The heights are given in feet and inches.

CASE I.

	1876, Sept. 3, Morning Tide, Anti-lunar and Solar.		1877, Aug. 23, Morning Tide, Anti-lunar and Solar.	
	d. h. m.	ft. in.	d. h. m.	ft. in.
Moon's Transit, B, .	1 10 39	25 5	21 10 35	25 4
Corr. for Anti-lunar, .		+ 1		+ 1
Moon's Hor. Parallax,	54' 45"	− 7	54' 3"	− 11
Anti-lunar Declination,	18° 12' N. des.	− 7	20° 41' N. des.	− 10
Solar Declination, .	8° N.	+ 4	12° N.	+ 4
	24 8 obs.	24 8	24 0 obs.	24 0
	Bar. 29 9. No wind.		Bar. 29·8. No wind.	

CASE II.

	1876, Sept. 10, Morning Tide, Lunar and Anti-solar.		1877, Aug. 21, Morning Tide, Lunar and Anti-solar.	
	d. h. m.	ft. in.	d. h. m.	ft. in.
Moon's Transit B, .	8 3 30	23 2	29 3 50	22 8
Corr. for Lunar, . .		+ 5		+ 5
Moon's Hor. Parallax,	57′ 53″ +	+ 7	55 50	− 3
Lunar Declination, .	20° 0′ N. asc.	− 4	19° 23′ N. asc.	− 2
Anti-solar Declination,	5° S.	+ 5	9° S.	+ 4
	24 3 obs.	24 3	23 7 obs.	22 11
	Bar. 29·7. No wind.		Bar. 29·6. Wind N.W., strong.	

It is to be observed that, in Case II., although the tide of September 10 has almost all its constituents more favourable to its development than those of August 31, still, in consequence of the atmospheric conditions, a higher tide results in the former case than in the latter.

In the computation of tides, the first thing which is of importance is, that we assign to each tide its proper classification. The transit which is to be employed, as a sort of standard transit from which tides are to be calculated, is the transit next but two preceding that transit which is nearest to the time of high water of the tide considered. This transit is, in fact, the transit B of Sir John Lubbock's Tables. The rule for determining the classification for the tides of the Irish Sea is as follows :—"Lower transits B are followed by lunar tides, and upper transits B by Anti-lunar tides. All transits B which take place between 23½ hours, and 11½ hours (apparent Greenwich time), give *morning* tides; and all between 11½ hours, and 23½ hours (apparent Greenwich time), give *evening* tides. All transits B, after 6 hours, and before 18 hours, are connected with solar tides; and all transits B, after 18 hours, and before 6 hours, with anti-solar tides."

A tabulated comparison of the results of theory and observation is appended, with remarks on the atmospheric conditions in explanation of such discrepancies as are found to occur in them.

TABULATED RESULTS.

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1876.		ft. in.	ft. in.	
August 8	M.	26·7	25·10	30·1, S. W.
	E.	25·2	24·5	
9	M.	26·5	25·10	30·1, W.
	E.	25·7	24·7	
10	M.	26·2	25·5	30·1, W. N. W.
	E.	23·11	23·7	
11	M.	25·4	24·9	30·3, E. S. E.
	E.	23·3	23·3	
12	M.	24·1	23·9	30·2, E. S E.
	E.	22·5	22·4	
13	M.	23·0	22·10	30·0, E. S. E.
	E.	21·1	21·6	
14	M.	21·5	21·7	30·0, W.
	E.	20·3	20·5	
15	M.	20·11	21·1	30·0, N. W.
	E.	21·0	21·0	
16	M.	21·8	21·9	30·0, E.
	E.	22·6	22·6	
17	M.	23·4	23·3	30·0, E. S. E.
	E.	24·10	24·10	
18	M.	25·6	25·4	29·9, E.
	E.	26·8	26·7	
19	M.	26·10	26·7	29·9, E. S. E.
	E.	28·2	28·2	
20	M.	28·0	27·9	29·8, N. E.
	E.	—	—	
21	M.	29·2	29·0	29·9, E. S. E.
	E.	28·3	27·9	
22	M.	29·1	28·9	29·9, W. N. W.
	E.	27·9	27·8	
23	M.	28·5	28·4	29·8, W. N. W.
	E.	26·10	26·9	
24	M.	26·9	26·11	29·8, W. N. W.
	E.	25·3	25·8	
25	M.	24·9	24·7	30·0, N. N. E.
	E.	23·5	23·5	
26	M.	22·10	23·2	30·0, S. W.
	E.	21·4	22·6	Strong wind, S. W. gale.
27	M.	20·9	21·6	29·1, W.
	E.	19·9	19·9	
28	M.	19·1	18·11	29·8, S. S. W.
	E.	18·9	19·4	Wind high.
29	M.	18·5	19·9	29·5, W.
	E.	19·1	19·4	

	Morning and Evening.	Calcula-tions.	Observa-tions.	Remarks. Barom. and Wind.
		ft. in.	ft. in.	
	M.	18·10	19·3	29·6, W. S. W.
	E.	20·2	22·9	Wind high, S.; bar. 29·2.
31	M.	20·6	21·4	29·0, W. S. W.
	E.	21·9	22·6	
1	M.	21·11	21·9	29·6, N. W.
	E.	23·10	24·1	
2	M.	23·5	23·4	29·8, N. N. E.
	E.	25·2	25·5	
3	M.	24·8	24·8	29·9, W. N. W.
	E.	26·3	26·3	
4	M.	25·9	26·2	29·5, E.
	E.	27·5	27·4	
5	M.	—	—	29·4, S.
	E.	26·6	26·6	
6	M.	28·0	28·0	29·4, S. W.
	E.	26·10	26·10	
7	M.	27·11	27·9	29·5, S.W.
	E.	26·4	26·4	
8	M.	27·2	26·10	29·6, W. N. W.
	E.	25·4	25·1	
9	M.	25·9	26·4	29·7, W.
	E.	24·3	24·3	
10	M.	24·3	24·3	29·7, W. N. W.
	E.	22·9	23·11	
11	M.	22·6	22·10	29·7, W. N. W.
	E.	21·2	21·7	
12	M.	20·8	20·7	29·8, N. W.
	E.	20·0	20·4	
13	M.	20·2	20·4	29·8, N. W.
	E.	20·9	20·11	
14	M.	21·5	21·6	29·8, W.
	E.	22·10	22·10	
15	M.	23·8	23·9	29·8, W.
	E.	25·4	25·4	
16	M.	25·8	25·5	29·7, S. E.
	E.	27·0	27·0	
17	M.	27·2	27·1	29·6, S.
	E.	28·6	28·7	
18	M.	27·11	27·9	29·7, S. W.
	E.	29·7	28·6	Bar. rising.
19	M.	—	—	30·0, W.
	E.	28·3	27·9	Bar. 30·1.
20	M.	28·6	28·1	Bar. 30·1, W.
	E.	27·7	27·3	
Sept. 21	M.	27·8	27·7	30·2, S. E.
	E.	26·6	26·5	

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1876.		ft. in.	ft. in.	
Sept. 22	M.	26·3	26·4	30·0, S. E.
	E.	25·3	25·3	
23	M.	24·4	24·5	29·8, S. E.
	E.	23·8	24·0	
24	M.	22·4	22·6	Bar. falling.
	E.	21·8	22·10	Bar. 29·9, S. E.
25	M.	20·5	21·3	29·5, S. W.
	E.	19·8	19·9	
26	M.	18·7	18·7	29·8, S.
	E.	18·6	18·7	
27	M.	17·6	17·6	29·6, W.
	E.	18·8	18·8	
28	M.	18·7	18·8	29·6, E.
	E.	20·2	20·3	
29	M.	20·4	20·5	29·4, W.
	E.	21·10	22·0	
30	M.	21·10	21·9	29·6, N. E.
	E.	24·9	23·5	Gale N. N. E.
Oct. 1	M.	23·8	23·5	29·6, N. E.
	E.	25·5	25·1	Bar. rising.
2	M.	24·11	24·5	30·1, E.
	E.	26·9	26·4	
3	M.	25·11	25·11	29·8, E. S. E.
	E.	27·9	27·9	
4	M.	27·3	27·2	29·7, S. E.
	E.	28·6	28·4	
5	M.	—	—	
	E.	27·1	27·4	29·8, E. S. E.
6	M.	28·2	28·1	29·8, S. E.
	E.	27·0	27·2	
7	M.	27·3	27·6	29·8, S. E.
	E.	26·1	26·6	
8	M.	25·10	26·2	29·9, S
	E.	24·7	24·11	
9	M.	24·3	24·7	Bar. fallen.
	E.	22·11	24·4	Bar. 29·4, S. E.
10	M.	22·4	23·5	29·4, S. W.
	E.	21·3	23·1	
11	M.	20·6	21·4	W. gales.
	E.	20·7	23·3	29·1, S.
12	M.	21·0	21·4	29·5, S.
	E.	21·8	22·6	
13	M.	22·4	22·11	29·6, S. W.
	E.	23·9	24·7	
14	M.	24·3	24·7	29·5, S.
	E.	25·8	26·3	

	Morning and Evening.	Calcula-tions.	Observa-tions.	Remarks. Barom. and Wind.
		ft. in.	ft. in.	
	M.	26·0	25·10	29·7, S.
	E.	27·0	27·2	
16	M.	27·0	27·5	29·6, S. E.
	E.	28·3	28·3	
17	M.	27·8	27·8	29·6, S. E.
	E.	28·3	28·5	
18	M.	27·9	27·9	29·6, S. E.
	E.	27·10	27·9	
19	M.	—	—	
	E.	27·1	26·10	Bar. 29·8, S.
20	M.	26·6	26·1	Bar. 30. 0, S. E.
	E.	25·10	25·9	
21	M.	25·2	25·0	30·1, N. E.
	E.	24·10	24·2	
22	M.	23·7	23·4	30·2.
	E.	23·3	22·11	
23	M.	21·7	21·6	
	E.	21·9	21·9	
24	M.	20·2	20·2	30·1, S. E.
	E.	20·3	20·6	
25	M.	18·7	18·7	30·2, S. E.
	E.	19·3	19·4	
26	M.	17·7	17·6	30·3, S. E.
	E.	19·3	19·2	
27	M.	18·8	18·5	30·3, S. E.
	E.	20·5	20·3	
28	M.	20·1	19·10	Bar. rising.
	E.	22·0	21·7	Bar. 30·3, S. E.
29	M.	21·10	22·0	Settled.
	E.	23·9	23·5	30·3, S. W.
30	M.	23·6	23·6	30·2, N. W.
	E.	25·7	25·2	
31	M.	25·1	24·5	Bar. 30·3, W.
	E.	26·11	26·0	Bar. 30·4
Nov. 1	M.	25·11	25·7	Bar. 30·4, N. E.
	E.	27·5	27·0	
2	M.	26·6	26·6	30·3, N. W.
	E.	27·10	27·8	
3	M.	27·1	27·3	30·2, S. W.
	E.	—	—	
4	M.	27·7	27·5	30·3, W. N. W.
	E.	26·8	26·7	
5	M.	26·8	26·5	30·3, W.
	E.	25·9	25·11	
6	M.	25·5	25·5	30·3, W.
	E.	24·6	24·6	

Date.	Morning and Evening.	Calcula-tions.	Observa-tions.	Remarks. Barom. and Wind.
1876.		ft. in.	ft. in.	
Nov. 7	M.	23·11	23·8	Wind W., slight.
	E.	23·3	23·4	30·3, N. E.
8	M.	22·5	22·0	Bar. 30·2, S. E.
	E.	22·0	22·2	
9	M.	21·1	20·11	30·1, N. E.
	E.	21·6	21·8	
10	M.	21·3	21·0	Frost.
	E.	22·3	22·4	30·2, N. E.
11	M.	22·5	23·0	Bar. fallen.
	E.	23·4	23·9	29·9, S. E.
12	M.	23·6	23·0	
	E.	24·9	24·6	29·7, E.
13	M.	24·10	24·8	29·3, E.
	E.	25·7	25·3	
14	M.	25·7	25·8	29·6, E.
	E.	26·3	27·3	Bar. fallen, S. S. W.
15	M.	25·10	26·6	29·4, S. E.
	E.	26·3	26·7	
16	M.	26·1	26·4	29·3, E. N. E.
	E.	26·2	26·10	S. W.
17	M.	26·2	26·8	29·8, S.
	E.	—	—	
18	M.	25·7	25·7	29·8, S.
	E.	25·8	26·0	
19	M.	24·9	25·3	Bar. 29·7, S.
	E.	24·7	25·6	Gradients.
20	M.	23·4	24·5	Southerly.
	E.	23·4	24·0	29·7, S. W.
21	M.	22·3	22·5	
	E.	22·6	23·0	Bar. 29·9, W.
22	M.	21·0	21·4	30·1, S. E.
	E.	21·5	22·3	S.
23	M.	19·9	20·3	30·1, S. E.
	E.	20·8	21·3	
24	M.	19·3	19·3	29·8, S. E.
	E.	20·6	20·6	
25	M.	19·0	18·11	29·6, S. E.
	E.	21·0	21·2	
26	M.	20·0	20·2	29·5, S. E.
	E.	22·0	22·3	
27	M.	21·2	21·5	29·4, S. E.
	E.	23·2	22·11	Wind E., slight.
28	M.	22·7	22·8	29·3, N.
	E.	24·6	24·6	
29	M.	24·3	24·5	29·4, W. S. W.
	E.	25·10	25·10	
30	M.	25·7	25·8	29·5, S.
	E.	26·7	26·6	

	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
		ft. in.	ft. in.	
	M.	26·10	26·11	Bar. fallen.
	E.	27·5	28·5	Bar. 29·2, S. E.
2	M.	27·5	27·6	
	E.	27·10	26·11	Gale N. E.; bar. 29·0.
3	M.	—	—	
	E.	27·8	28·6	Bar. fallen; wind S. W.
4	M.	27·8	28·5	Bar. 28·9.
	E.	26·11	28·5	Stormy.
5	M.	26·6	27·6	Bar. 28·5.
	E.	26·2	27·7	
6	M.	25·2	27·6	Gale S. W.
	E.	25·2	27·0	Bar. 28·9.
7	M.	24·3	25·0	Unsettled.
	E.	24·0	25·3	Stormy.
8	M.	22·11	23·6	29·6, N. W.
	E.	22·11	24·2	
9	M.	22·0	22·3	30·0, W.
	E.	22·9	23·6	
10	M.	22·7	22·7	30·1, S. W.
	E.	23·1	23·7	
11	M.	22·10	23·1	30·0, S.
	E.	23·6	23·8	
12	M.	23·4	24·7	29·6, W. S. W.
	E.	23·11	24·0	
13	M.	24·1	24·1	29·6, S.
	E.	24·3	24·9	Bar. fallen.
14	M.	24·8	25·1	29·7, S.
	E.	24·8	24·5	
15	M.	25·1	25·1	29·8, S.
	E.	24·8	24·8	
16	M.	25·4	25·4	29·7, S.
	E.	24·9	24·7	
17	M.	—	—	
	E.	25·5	25·7	29·6, S.
18	M.	24·6	24·2	29·5, S. E.
	E.	25·4	25·2	
19	M.	23·10	23·10	29·1, S.
	E.	24·10	25·0	
20	M.	23·3	23·3	
	E.	24·4	25·0	Bar. fallen, 28·9.
21	M.	22·8	22·6	Bar. steady.
	E.	23·9	24·3	Gale W.
22	M.	22·3	22·5	28·9, W.
	E.	23·3	23·3	
23	M.	21·7	21·4	29·1, S.
	E.	22·8	22·7	

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1876.		ft. in.	ft. in.	
Dec. 24	M.	21·0	20·2	Wind E.; frost.
	E.	22·1	21·3	29·4, S. E.
25	M.	20·6	19·5	29·6, N. E.
	E.	21·10	20·10	,, ,,
26	M.	20·9	19·8	30·1, E.
	E.	22·4	21·5	
27	M.	21·8	23·1	Bar. falling; gale.
	E.	23·1	23·11	S. W.; 29·4.
28	M.	23·0	23·4	29·4, S.
	E.	24·5	24·4	
29	M.	24·9	24·7	29·5, S.
	E.	25·10	27·0	Bar. falling.
30	M.	25·10	26·9	,,
	E.	26·11	27·7	Bar. 29·0, S.
31	M.	27·5	29·6	,, 29·0, S. W.
	E.	27·10	29·0	Bar. falling; gale, S. W.
1877.				
Jan. 1	M.	—	—	
	E.	28·4	29·7	28·8, S.
2	M.	28·3	27·8	Wind W.; Bar. rising, frost.
	E.	28·5	28·8	
3	M.	27·10	27·3	Gale, S. E.
	E.	27·11	27·6	,, ,,
4	M.	27·1	27·0	
	E.	27·0	28·9	Bar. falling; wind S. W.
5	M.	25·10	26·6	Bar. 29·0; S. W.
	E.	25·10	27·0	,, ,,
6	M.	24·4	25·0	,, ,,
	E.	24·3	25·5	Bar. 28·8; stormy.
7	M.	22·9	24·9	,, ,, ,,
	E.	22·6	25·0	High winds, S.
8	M.	21·10	23·1	Bar. 29·1; storm, S. W.
	E.	21·5	22·8	,, ,, ,,
9	M.	21·4	22·0	29·4, S. W.
	E.	21·1	21·9	
10	M.	21·5	21·6	29·9, S. E.
	E.	21·4	21·6	
11	M.	22·2	22·2	29·9, N. E.
	E.	22·0	22·2	Settled and cold.
12	M.	23·1	23·3	29·0, E.
	E.	22·9	22·6	
13	M.	23·11	24·1	Bar. falling.
	E.	23·4	24·0	Wind S.
14	M.	24·8	25·4	Signal flying; Bar. 29·0.
	E.	24·0	25·1	High wind.
15	M.	25·6	25·4	29·8, N. W.
	E.	—	—	

		Morning and Evening.	Calcula-tions.	Observa-tions.	Remarks. Barom. and Wind.
			ft. in.	ft. in.	
		M.	24·10	24·11	29·9, S.
		E.	26·1	26·2	
		M.	25·0	25·1	29·7, S.
		E.	26·1	26·1	
	18	M.	24·8	24·9	Bar. falling fast.
		E.	25·9	27·0	29·5, S. W.
	19	M.	24·4	24·8	Unsettled.
		E.	25·3	27·0	Gale, S. W.
	20	M.	23·10	23·4	Sudden rise of Bar.
		E.	25·0	24·10	30·1, S.
	21	M.	23·2	22·11	Bar. 30·3.
		E.	24·3	24·1	Wind W.
	22	M.	22·2	21·10	Bar. 30·4, S.
		E.	23·2	22·7	,, ,,
	23	M.	21·3	21·5	30·4, S. E.
		E.	21·10	22·1	Bar. falling.
	24	M.	20·7	20·11	30·0, S.
		E.	21·1	21·0	,,
	25	M.	20·7	21·5	Gale, W.
		E.	21·7	21·9	30·0, S.
	26	M.	21·9	20·10	Gale, W.; Bar. 30·0.
		E.	22·10	22·7	,,
	27	M.	23·4	24·2	Wind S.; Bar. falling.
		E.	24·7	24·3	Sudden rise, 30·0.
	28	M.	25·4	27·6	Gale, W.; Bar. falling.
		E.	26·4	27·8	29·8, S. W.
	29	M.	27·5	27·6	Wind W.; Bar. rising.
		E.	27·10	29·0	Gale, S. W.; 29·9.
	30	M.	28·9	31·0	Hurricane, S.W.; Bar. 29·0.
		E.	—	—	
	31	M.	28·9	28·2	Bar. sudden rise to 30·0;
		E.	29·5	29·6	[N. W.
Feb.	1	M.	28·9	29·4	Sudden fall of Bar.
		E.	29·1	29·5	29·8, S. W.
	2	M.	27·9	28·0	29·7, S.
		E.	28·0	28·11	Further fall.
	3	M.	26·8	27·4	Wind S. W.
		E.	26·5	28·5	29·8, S. W.
	4	M.	24·9	25·8	Gale, W. N. W.
		E.	24·2	24·6	29·9, W.
	5	M.	23·0	23·3	30·1, W.
		E.	22·2	23·3	
	6	M.	21·0	21·0	30·0, S.
		E.	20·2	21·5	Bar. falling.
	7	M.	19·9	20·3	Wind high.
		E.	19·3	19·5	30·0, W.

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1877.		ft. in.	ft. in.	
Feb. 8	M.	19·8	19·6	30·1, W.
	E.	19·8	20·0	
9	M.	20·7	20·10	30·1, S. W.
	E.	20·6	21·6	Bar. falling; wind S.W.
10	M.	21·9	22·6	Wind high.
	E.	21·10	22·2	29·8, S. W.
11	M.	23·6	24·9	Gale, S. W.
	E.	22·9	23·3	Bar. still falling.
12	M.	24·7	26·7	
	E.	23·10	24·6	29·6, S. W.
13	M.	25·7	25·11	29·6, W.
	E.	25·0	25·0	
14	M.	26·7	26·11	29·7, S.
	E.	—	—	
15	M.	25·8	25·11	29·8, S.
	E.	27·3	27·5	
16	M.	25·10	26·1	29·6, S.
	E.	27·3	27·4	
17	M.	25·7	25·8	29·8, W.
	E.	26·9	26·0	Wind W,, strong.
18	M.	25·0	25·0	Bar. 30·0.
	E.	25·10	25·7	,, 29·7.
19	M.	24·1	24·5	Wind N. W.
	E.	24·8	24·11	29·9, W.
20	M.	22·11	25·6	Gale N. W.; Bar. 29·4.
	E.	23·4	25·6	,, ,,
21	M.	21·6	24·0	Stormy; Bar. rising.
	E.	21·10	20·4	Wind N. E.; Bar. 30·0.
22	M.	20·1	19·6	Wind N. E.; Bar. 30·2.
	E.	20·5	20·8	,, N. W.
23	M.	19·6	17·8	Wind N.; cold.
	E.	20·6	20·3	30·0, N. W.
24	M.	20·10	21·2	High wind, W. N. W.
	E.	22·0	22·6	Bar. falling.
25	M.	23·3	24·6	Gale, N. W.
	E.	24·5	24·7	Bar. 29·2.
26	M.	25·9	25·6	Wind N.
	E.	26·3	26·0	Frost.
27	M.	27·8	27·8	29·8, N. W.
	E.	27·11	27·7	,,
28	M.	29·2	28·8	Hard frost; wind N.
	E.	28·9	28·3	Bar. 30·1.
March 1	M.	—	—	
	E.	29·10	29·8	Wind S.; Bar. falling
2	M.	29·0	28·11	[slowly.
	E.	29·9	29·8	30·1, S.

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1877.		ft. in.	ft. in.	
March 3	M.	28·0	28·0	30·1, S. W.
	E.	28·4	28·7	29·9, S.
4	M.	26·6	26·6	29·9, S.
	E.	26·3	26·4	29·9, N. W.
5	M.	24·8	24·6	
	E.	23·10	23·8	29·9, N. W.
6	M.	22·7	22·1	30·0, N. W.
	E.	21·6	21·8	Bar. falling; wind N. W.
7	M.	20·7	20·8	29·6, S.
	E.	18·11	17·7	Gale, N.; Bar. 30·0.
8	M.	18·5	17·0	Wind N., ,,
	E.	17·4	16·6	,, ,,
9	M.	18·5	18·0	,, ,,
	E.	18·2	18·0	30·1, E.
10	M.	19·8	19·6	30·1, S.
	E.	19·6	20·0	30·1, S. W.
11	M.	21·5	21·6	30·1, S.
	E.	21·3	21·3	
12	M.	23·2	24·2	30·0, S.W.; fall of ½ inch.
	E.	22·9	23·6	Strong gale.
13	M.	24·8	24·9	Rising; wind N. N. W.
	E.	24·2	24·6	Gale, N. W.
14	M.	26·0	26·4	,, 29·7.
	E.	25·3	25·0	,,
15	M.	27·2	27·2	29·6, W.
	E.	26·4	27·0	Gale, W.
16	M.	28·1	27·7	Wind N.N.W., 29·0; Bar. [rising.
	E.	—	—	
17	M.	26·10	26·2	N. N. W., 29·5.
	E.	28·1	27·3	N.
18	M.	26·6	26·6	
	E.	27·3	27·1	
19	M.	25·9	25·6	
	E.	26·3	26·0	
20	M.	24·7	24·7	Frost, 29·8.
	E.	24·8	24·10	
21	M.	23·5	23·7	N. E.; 29·4.
	E.	23·3	23·6	
22	M.	22·0	22·4	
	E.	20·3	21·7	
23	M.	20·3	20·7	S., strong; 29·3.
	E.	19·9	20·9	
24	M.	19·8	20·0	
	E.	20·8	20·8	
25	M.	21·5	20·10	S. E., gale.
	E.	22·3	22·2	,,

Date.	Morning and Evening.	Calculations.	Observations.	Remarks. Barom. and Wind.
1877.		ft. in.	ft. in.	
March 26	M.	23·10	23·11	
	E.	24·10	25·3	S. Wind, strong.
27	M.	26·4	26·7	,, ,,
	E.	26·11	27·5	Stormy.
28	M.	28·1	28·3	,,
	E.	28·1	28·1	
29	M.	29·3	29·2	
	E.	28·10	28·8	
30	M.	29·5	29·2	
	E.	—	—	
31	M.	28·10	28·8	
	E.	28·10	29·1	W.
April 1	M.	27·11	27·7	N. N. W., cold.
	E.	27·4	27·6	
2	M.	26·3	26·6	W. S. W.
	E.	25·4	25·7	
3	M.	24·5	25·4	Bar. falling fast; signal fly-
	E.	23·2	23·11	Bar. 29·3. [ing; wind S.
4	M.	22·9	23·11	,, 29·0.
	E.	21·4	22·1	,, ,,
5	M.	20·8	22·3	Unsettled.
	E.	19·2	19·11	,,
6	M.	19·1	20·0	,,
	E.	17·9	18·3	,,
7	M.	18·10	18·11	
	E.	18·4	18·4	
8	M.	19·10	20·0	
	E.	19·9	20·0	
9	M.	21·5	21·6	
	E.	21·4	21·7	
10	M.	23·0	23·2	
	E.	23·0	23·4	
11	M.	24·7	24·4	
	E.	24·3	24·0	Bar rising.
12	M.	26·0	25·4	N., gusty.
	E.	25·5	25·3	
13	M.	26·10	26·6	
	E.	26·0	25·11	
14	M.	27·3	26·6	S. E., strong; Bar. 30·0.
	E.	26·6	26·0	,, ,,
15	M.	—	—	
	E.	27·7	26·7	S. E., gale; Bar. 29·8.
16	M.	26·7	26·0	S. E., ,, ,, 29·8.
	E.	26·10	25·7	E. ,, ,, ,,
17	M.	25·11	25·3	E. ,, ,, ,,
	E.	25·9	25·2	E., Bar. 29·8.

	ng ng.	Calculations.	Observations.	Remarks. Barom. and Wind.
		ft. in.	ft. in.	
	M.	24·9	24·9	
	E.	24·3	24·3	
19	M.	23·3	23·3	
	E.	22·9	22·8	
20	M.	22·1	22·3	
	E.	21·4	21·4	S. W.; Bar. falling.
21	M.	21·0	21·9	Unsettled.
	E.	20·6	20·9	
22	M.	21·2	21·4	
	E.	21·2	21·3	
23	M.	22·4	22·2	
	E.	23·0	22·11	
24	M.	24·0	23·9	
	E.	24·7	24·6	
25	M.	25·11	25·7	S. E.; 29·8.
	E.	26·2	25·10	S. E.; 29·9.
26	M.	27·2	26·7	S. E., strong; 30·0.
	E.	26·11	26·7	S. E.; 29·8.
27	M.	27·6	26·11	S. E., strong; 29·8.
	E.	27·1	26·11	" " 29·9.
28	M.	27·4	27·3	
	E.	27·0	27·0	
29	M.	—	—	
	E.	27·0	26·10	
30	M.	26·8	26·5	N., frosty; 29·8.
	E.	25·8	25·9	N. W.; 30·0.

XX.—DISCUSSION OF OBSERVATIONS FOR DETERMINING THE PARALLAX OF THE PLANETARY NEBULA, 37, H. IV. MADE WITH THE SOUTH EQUATORIAL AT DUNSINK. By FRANCIS BRÜNNOW, Ph. D., F. R. A. S.

[Read, November 12, 1877.]

AT the Meeting of the British Association for the Advancement of Science, held at Edinburgh in 1871, Mr. Gill read a Paper on the "Parallax of the Planetary Nebula H. IV., 37," for which he had found a value of about two seconds. However, the number of his observations was so small, that it seemed to me advisable to make a longer series of observations of this interesting object, in order to examine whether such a large parallax really existed. The observations were commenced immediately after my return home on August 13, 1871, and were continued to August 6, 1872, with some interruptions owing to my absence from the Observatory during the months of January and February, 1872, and again during part of April and May. They are, therefore, not as numerous as I could have wished, but still are sufficient to show that the nebula has no large parallax.

The nebula appears as a somewhat elliptical disk whose major axis is about half a minute, and has in its centre a well-defined point resembling a star of the eleventh magnitude. I compared this centre in declination with a star of the tenth magnitude which precedes the nebula by 25 seconds, using exactly the same method of observing as that adopted in my former series of observations on the parallax of stars. I also used a faintly illuminated field, as I could make the bisections of these faint objects more accurately with dark wires than in a dark field with bright wires. Of course, I observed only when the atmosphere was sufficiently good to show the central point distinctly.

The observations I have obtained are as follows:—

Date.		$\Delta\delta$ expressed in rev. of the screw.	Therm.	$\Delta\delta$ in seconds.	Weight.
1871.					
August	13,	6·95815	55°·0	62″·561	
,,	15,	6·95670	54 ·0	62 ·551	
,,	25,	7·02535	50 ·5	63 ·176	
,,	27,	6·98780	52 ·0	62 ·834	
September	11,	6·99955	53 ·0	62 ·939	
,,	12,	6·98115	54 ·0	62 ·773	
,,	13,	6·98390	52 ·0	62 ·799	
,,	21,	6·98320	42 ·0	62 ·813	

Date.		Δδ expressed in rev. of the screw.	Ther.	Δδ in seconds.	Weight.
1871.					
September	23,	6·95920	40°·0	62″·603	
,,	28,	6·97930	42 ·0	62 ·779	
October	7,	6·99335	39 ·5	62 ·910	
,,	20,	6·99180	41 ·0	62 ·894	
,,	21,	7·00335	44 ·5	62 ·990	
,,	24,	6·99310	43 ·5	62 ·900	
November	5,	6·99390	37 ·0	62 ·921	
,,	22,	6·98395	38 ·5	62 ·827	
December	16,	6·99230	37 ·0	62 ·907	
,,	19,	6·99590	39 ·0	62 ·933	
,,	20,	6·97100	37 ·0	62 ·716	
1872.					
January	6,	6·97640	35 ·0	62 ·767	
March	1,	7·02915	42 ·5	63 ·227	$\frac{4}{5}$
,,	8,	7·01055	37 ·0	63 ·071	
,,	14,	7·01730	39 ·0	63 ·126	
,,	17,	7·01220	39 ·5	63 ·080	
April	3,	7·00625	35 ·0	63 ·034	
,,	12,	7·01195	40 ·0	63 ·077	
,,	13,	7·00485	41 ·0	63 ·011	
May	31,	7·00490	44 ·0	63 ·004	
June	5,	6·99815	44 ·0	62 ·943	
,,	7,	7·00085	45 ·5	62 ·966	
July	14,	6·98540	56 ·0	62 ·806	
August	2,	6·99450	52 ·0	62 ·896	
,,	6,	6·99410	53 ·0	62 ·891	

The observed apparent differences of declination must first be corrected for refraction and aberration, and reduced to a mean equinox, for which I chose as epoch the beginning of the year 1872. The effect of refraction is in this case very small, and nearly constant, as is shown by the following Table, because all the observations were made at considerable altitudes :—

Hour Angle.	Corr. for Refr.	Hour Angle.	Corr. for Refr.
0^h	+ 0″·019	4^h	+ 0″·018
1	+ 0 ·018	5	+ 0 ·018
2	+ 0 ·018	6	+ 0 ·021
3	+ 0 ·018	7	+ 0 ·026

The effect of aberration, nutation, and precession, is given in the following Table, which has been computed from the formulæ on page 38 of Part I.[1]:—

Date.		Reduction to Mean $\Delta\delta$.	Date.		Reduction to Mean $\Delta\delta$.
1871.			1872.		
August	7·7,	$-0''\cdot050$	February	9·5,	$+0''\cdot014$
,,	17·7,	0 ·044	,,	19·5,	0 ·010
,,	27·6,	0 ·038	,,	29·4,	0 ·006
Sept.	6·6,	0 ·032	March	10·4,	+ 0 ·001
,,	16·6,	0 ·026	,,	20·4,	− 0 ·005
,,	26·5,	0 ·019	,,	30·3,	0 ·010
October	6·5,	0 ·013	April	9·3,	0 ·015
,,	16·5,	0 ·007	,,	19·3,	0 ·019
,,	26·5,	− 0 ·001	,,	29·3,	0 ·023
Nov.	5·4,	+ 0 ·005	May	9·2,	0 ·026
,,	15·4,	0 ·010	,,	19·2,	0 ·028
,,	25·4,	0 ·014	,,	29·2,	0 ·029
December	5·4,	0 ·018	June	8·1,	0 ·030
,,	15·3,	0 ·020	,,	18·1,	0 ·029
,,	25·3,	0 ·022	,,	28·1,	0 ·027
,,	35·3,	0 ·022	July	8·1,	0 ·025
1872.			,,	18·0,	0 ·022
January	0·6,	0 ·022	,,	28·0,	0 ·018
,,	10·6,	0 ·021	August	7·0,	0 ·013
,,	20·5,	0 ·020	,,	17·0,	0 ·007
,,	30·5,	0 ·018	,,	26·9,	− 0 ·001

From these Tables I found the small corrections for every observation, which are given in the first two columns of the following Table, and by applying them to the observed values of $\Delta\delta$, given above, I obtained the reduced values $\Delta\delta$, which are given in the last column of the following Table:—

Date.		Refr.	Red.	Sum.	$\Delta\delta$.
1871.					
August	13,	$+0''\cdot018$	$-0''\cdot046$	$-0''\cdot028$	$62''\cdot533$
,,	15,	+ 0 ·018	− 0 ·045	− 0 ·027	62 ·524
,,	25,	+ 0 ·018	− 0 ·039	− 0 ·021	63 ·155
,,	27,	+ 0 ·018	− 0 ·038	− 0 ·020	62 ·814
September	11,	+ 0 ·018	− 0 ·029	− 0 ·011	62 ·928
,,	12,	+ 0 ·018	− 0 ·028	− 0 ·010	62 ·763

[1] Astronomical Observations made at Dunsink, 1871.

Date.		Refr.	Red.	Sum.	Δδ.
1871.					
September	13,	+ 0″·018	− 0″·028	− 0″·010	62″·789
,,	21,	+ 0 ·018	− 0 ·022	− 0 ·004	62 ·809
,,	23,	+ 0 ·018	− 0 ·021	− 0 ·003	62 ·600
,,	28,	+ 0 ·018	− 0 ·018	− 0 ·000	62 ·779
October	7,	+ 0 ·020	− 0 ·012	+ 0 ·008	62 ·918
,,	20,	+ 0 ·019	− 0 ·005	+ 0 ·014	62 ·908
,,	21,	+ 0 ·022	− 0 ·004	+ 0 ·018	63 ·008
,,	24,	+ 0 ·020	− 0 ·002	+ 0 ·018	62 ·918
November	5,	+ 0 ·023	+ 0 ·005	+ 0 ·028	62 ·949
,,	22,	+ 0 ·018	+ 0 ·013	+ 0 ·031	62 ·858
December	16,	+ 0 ·018	+ 0 ·020	+ 0 ·038	62 ·945
,,	19,	+ 0 ·019	+ 0 ·021	+ 0 ·040	62 ·973
,,	20,	+ 0 ·018	+ 0 ·021	+ 0 ·039	62 ·755
1872.					
January	6,	+ 0 ·023	+ 0 ·021	+ 0 ·044	62 ·811
March	1,	+ 0 ·025	+ 0 ·005	+ 0 ·030	63 ·257
,,	8,	+ 0 ·023	+ 0 ·002	+ 0 ·025	63 ·096
,,	14,	+ 0 ·024	− 0 ·001	+ 0 ·023	63 ·149
,,	17,	+ 0 ·022	− 0 ·004	+ 0 ·018	63 ·098
April	3,	+ 0 ·018	− 0 ·012	+ 0 ·006	63 ·040
,,	12,	+ 0 ·018	− 0 ·016	+ 0 ·002	63 ·079
,,	13,	+ 0 ·018	− 0 ·017	+ 0 ·001	63 ·012
May	31,	+ 0 ·018	− 0 ·030	− 0 ·012	62 ·992
June	5,	+ 0 ·018	− 0 ·030	− 0 ·012	62 ·931
,,	7,	+ 0 ·018	− 0 ·030	− 0 ·012	62 ·954
July	14,	+ 0 ·018	− 0 ·023	− 0 ·005	62 ·801
August	2,	+ 0 ·018	− 0 ·015	+ 0 ·003	62 ·899
,,	6,	+ 0 ·018	− 0 ·014	+ 0 ·004	62 ·895

If we take then $\Delta\delta_0$ as a mean value of $\Delta\delta$, $d\Delta'$ as the difference of the proper motions of the star and nebula, and denote the difference of the parallax of the nebula from that of the star by π, that of the constants of aberration for the two objects by κ every observation will give us an equation of the form:

$$0 = \Delta\delta_0 - \Delta\delta + d.\,\Delta\delta_0 + t.\,d\Delta' - b.\,R.\,\cos(\odot + B).\,\pi - b.\,\sin(\odot + B).\,\kappa.$$

The values of the constant quantities B and b were found from the well-known formulæ

$$B = 270^\circ - 19', \qquad b = 1{\cdot}0000,$$

the latter value being equal to unity, because the nebula is close to the North Pole of the Ecliptic.

Taking, then, for $\Delta\delta_0$ the value $62''\cdot900$, and computing the values of the coefficients of $d\Delta'$, κ, and π for every observation, I obtained the following system of equations of condition :—

Date.	Equations.				Residual Errors.
1871.					
Aug. 13,	$d.\Delta\delta_0 - 0\cdot382\, d\Delta'$	$-0\cdot778\ \kappa$	$-0\cdot637\ \pi$	$= -0''\cdot367$	$-0''\cdot260$
„ 15,	−0·376	−0·798	−0·609	−0 ·376	−0 ·268
„ 25,	−0·349	−0·888	−0·465	+0 ·255	+0 ·366
„ 27,	−0·343	−0·903	−0·434	−0 ·086	+0 ·026
Sept. 11,	−0·303	−0·982	−0·191	+0 ·028	+0 ·138
„ 12,	−0·300	−0·985	−0·175	−0 ·137	−0 ·029
„ 13,	−0·297	−0·988	−0·158	−0 ·111	−0 ·003
„ 21,	−0·275	−1·000	−0·022	−0 ·091	+0 ·013
„ 23,	−0·270	−1·000	+0·013	−0 ·300	−0 ·198
„ 28,	−0·256	−0·995	+0·099	−0 ·121	−0 ·024
Oct. 7,	−0·231	−0·968	+0·250	+0 ·018	+0 ·106
„ 20,	−0·196	−0·888	+0·458	+0 ·008	+0 ·076
„ 21,	−0·193	−0·879	+0·473	+0 ·108	+0 ·175
„ 24,	−0·185	−0·854	+0·517	+0 ·018	+0 ·079
Nov. 5,	−0·152	−0·727	+0·681	+0 ·049	+0 ·089
„ 22,	−0·106	−0·495	+0·858	−0 ·042	−0 ·039
Dec. 16,	−0·040	−0·092	+0·980	+0 ·045	−0 ·006
„ 19,	−0·032	−0·039	+0·983	+0 ·073	+0 ·014
„ 20,	−0·029	−0·021	+0·983	+0 ·145	−0 ·206
1872.					
Jan. 6,	+0·017	+0·278	+0·945	−0 ·089	−0 ·185
March 1,	+0·069	+0·952	+0·304	+0 ·357	+0 ·190
„ 8,	+0·188	+0·982	+0·188	+0 ·196	+0 ·026
„ 14,	+0·204	+0·996	+0·086	+0 ·249	+0 ·079
„ 17,	+0·212	+0·999	+0·034	+0 ·198	+0 ·029
April, 3,	+0·259	+0·966	−0·257	+0 ·140	−0 ·021
„ 12,	+0·284	+0·975	−0·404	+0 ·179	+0 ·025
„ 13,	+0·286	+0·908	−0·420	+0 ·112	−0 ·040
May 31,	+0·417	+0·325	−0·960	+0 ·092	+0 ·008
June 5,	+0·431	+0·244	−0·984	+0 ·031	−0 ·044
„ 7,	+0·437	+0·213	−0·992	+0 ·054	−0 ·019
July 14,	+0·538	+0·393	−0·935	−0 ·099	−0 ·116
Aug. 2,	−0·590	−0·659	−0·763	−0 ·001	+0 ·002
„ 6,	−0·601	−0·708	−0·716	−0 ·005	+0 ·001

In solving these equations according to the method of least squares, the weight of all observations, with the exception of that of March 1, 1872, which is incomplete, has been taken equal to 1. I obtained

thus the following final equations for determining the unknown quantities:—

$+\ 33{\cdot}0000$	$d.\Delta\delta_0$	$+\ 0{\cdot}3172$	κ	$-\ 8{\cdot}2603$	$d.\Delta'$	$-\ 1{\cdot}2703$	π	$= +\ 0''{\cdot}2400$
$+\ 0{\cdot}3172$	,,	$+\ 3{\cdot}1428$	,,	$+\ 4{\cdot}6399$	,,	$-\ 2{\cdot}5263$	,,	$= +\ 0\ {\cdot}7179$
$-\ 8{\cdot}2603$	,,	$+\ 4{\cdot}6399$	,,	$+\ 20{\cdot}5923$	,,	$+\ 0{\cdot}1074$	,,	$= +\ 2\ {\cdot}4580$
$-\ 1{\cdot}2703$	,,	$-\ 2{\cdot}5263$	,,	$+\ 0{\cdot}1074$	,,	$+\ 12{\cdot}4156$	,,	$= +\ 0\ {\cdot}3016.$

The solution of these equations gives the following values:—

$$d.\Delta\delta_0 = +\ 0''{\cdot}036$$
$$d\Delta' = +\ 0\ {\cdot}0978$$
$$\kappa = +\ 0\ {\cdot}112$$
$$\pi = +\ 0\ {\cdot}047.$$

The errors which remain in the equations of condition after the substitution of these values are given in the last column of the preceeding Table.

The squares of the errors are thereby reduced from $0''{\cdot}899$ to $0{\cdot}532$, which gives for the probable error of one observation the value $\pm\ 0''{\cdot}09$, and for the probable errors of the quantities above:—

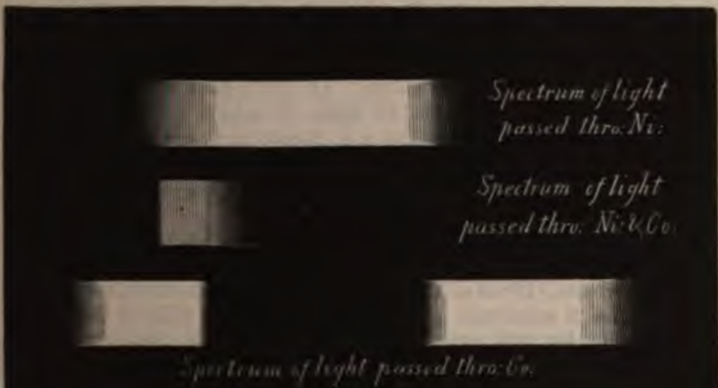
$(d.\Delta\delta_0)$	$\pm\ 0''{\cdot}018$
$d\Delta'$	$\pm\ 0\ {\cdot}0759$
κ	$\pm\ 0\ {\cdot}029$
π	$\pm\ 0\ {\cdot}030.$

XXI.—ON THE COLOUR RELATIONS AND COLORIMETRIC ESTIMATION OF NICKEL AND COBALT. By THOMAS BAYLEY, Associate R. C. Sc. I.

[Read, November 12, 1877.]

THE fact will have been observed by chemists that solutions of nickel and cobalt salts are so far complementary in colour that, when they are mixed together, the resulting liquid, if moderately dilute, is hardly to be distinguished from pure water. I conceived this fact might be made the basis of a method for estimating nickel and cobalt, and, therefore, undertook the following experiments.

A large hollow prism, filled with a moderately strong solution of a nickel or cobalt salt, was placed immediately in front of the slit of the spectroscope, and the thickness of the liquid traversed by the light was regulated by moving the prism until the eye could most clearly determine the dark absorption band caused by the metal in solution. On referring to the accompanying diagram, which shows the absorption spectra of the two metals, it will be seen that cobalt and nickel are almost exactly complementary in their relations to light. The black band of cobalt is well defined at the edges, especially at the end nearest to the red, while the absorption bands of nickel are not so sharply defined, but fade away at each end. If the spectra were exactly complementary, on superimposing the nickel spectrum upon the cobalt spectrum, the dark part on the one would exactly cover the light part on the other. This, however, though nearly the case, is not exactly so, for the light band in the nickel spectrum overlaps the dark cobalt band at the end nearest to the red, although with diminished brilliancy. Consequently, when we employ a mixture of nickel and cobalt salts in solution, we do not get a uniformly dark



spectrum, but an excess of light coming through at the part where the overlapping occurs, as seen in the diagram. This is why the so-

lution obtained by mixing strong solutions of nickel and cobalt is not grey, but reddish brown in colour.

Having so far demonstrated the complementary character of the two metals, I next endeavoured to find in what proportions they must be mixed in order to neutralize each other. For this purpose a tall glass cylinder (150 c. c. capacity), in which ammonia is estimated by Nessler's method, was employed. Dilute standard solutions of pure nickel and cobalt having been carefully prepared, a measured quantity of cobalt solution was placed in the cylinder, and the nickel added from a burette, until the neutral point was reached. It is difficult by this method to distinguish the exact point of neutrality, but easy to determine that the colour coefficient of nickel with regard to cobalt lies between 3·1 and 3·2. That is to say, if a quantity of cobalt in solution be mixed with a solution containing 3·1 times its weight of nickel, the cobalt colour will slightly predominate in the mixture, which will have a reddish tinge; while, if a solution containing 3·2 times its weight of nickel be added, the nickel colour will be slightly in excess, and the solution will have an olive green tinge. It is only with dilute solutions containing not more than about 2·5 grams of the metals per litre, that it is possible to determine the coefficient with this accuracy.

I now sought for some method of indicating more exactly the neutral point. After several attempts it was found that the addition of ammonium carbonate to the solution of the two metals affords a means of determining whether the slightest excess of either metal is present.

If we take 25 c. c. of solution containing ·03125 gram of cobalt, and add to this 39·25 c. c. of solution containing ·098125 gram of nickel, the resulting liquid appears perfectly colourless. If we now dilute the mixed solutions to 100 c. c. and transfer 25 c. c. of that solution, containing ·0078125 gram of cobalt, and ·02453125 gram of nickel, to a tall glass jar, add 25 c. c. of the solution of ammonium carbonate, described hereafter, and then dilute to 150 c. c., the result is a liquid of deep purple colour. If we repeat this experiment, using in the first instance ·03125 gram of cobalt, and ·099375 gram of nickel, the colour of the 150 c. c. is not purple, but of a distinct blue colour. The ammonium carbonate for this purpose must be neutral, as the excess of either base or acid destroys the delicacy of the reaction.

The solution of neutral carbonate $(NH_4)_2CO_3$ was prepared as follows. A few ounces of the commercial carbonate having been dissolved in water, 10 c. c. of the solution were neutralized by standard solution of sulphuric acid. The quantity of NH_3 in the 10 c. c. was found to be ·085 gramme. The quantity of CO_2 in an equal quantity of the solution was found to be in two experiments ·348 gram, and ·350 gram (mean ·349 gram): the amount of CO_2 required to form the neutral carbonate with ·085 gram of NH_3 being ·110, it follows that there was an excess of CO_2 equal to ·259 gram in every 10 c. c. of the original solution of commercial carbonate. To neu-

tralize this, 18 grams of ammonia were required to be added to a litre of the commercial carbonate solution. This was furnished by 61·7 c. c. of ammonia solution (of sp. gr. ·880).

I next endeavoured to determine whether the nature of the salt of nickel or cobalt has any effect on the reaction. For this purpose the following solutions were prepared:—

$Co\,Cl_2$ 1 c. c. = ·00125 grm. Co.
$Ni\,Cl_2$ 1 c. c. = ·0025 grm. Ni.
$Ni(NO_3)_2$ 1 c. c. = ·0025 grm. Ni.
$Ni\,SO_4$ 1 c. c. = ·0025 grm. Ni.
$Co\,(NO_3)_2$ 1 c. c. = ·00125 grm. Co.
$Co\,SO_4$ 1 c. c. = ·00125 grm. Co.

The method of proceeding was as follows:—In each of five cylinders 25 c. c. of the standard solution of cobaltous chloride were placed; to the first cylinder 39 c. c. of the solution of nickelous chloride were added; to the second cylinder 39·25 c. c., and so on; 40 c. c. of nickelous chloride being added to the fifth cylinder. Each cylinder was then made up to 100 c. c., and 25 c. c. out of each 100 c. c., were placed in a second series of cylinders. To each of the second series neutral ammonium carbonate (25 c. c.) was added, and then sufficient water to make 150 c. c. The results are expressed in the following Table:—

Cylinder.	Co used.	Ni used.	Colour.	Ratio of Ni to Co.
(1)	·03125 grm.	·09750 grm.	purple.	3·12
(2)	·03125 ,,	·098125 ,,	slightly purple.	3·14
(3)	·03125 ,,	·098750 ,,	between 2 & 4.	3·16
(4)	·03125 ,,	·099375 ,,	slightly blue.	3·18
(5)	·03125 ,,	·10000 ,,	blue.	3·20

In two experiments, using in the first solutions of $Co\,Cl_2$ and $Ni\,SO_4$, and in the second solutions of $Co\,Cl_2$ and $Ni\,(NO_3)_2$, I obtained exactly the same results, so that the foregoing Table expresses the results of these experiments. Subsequently experiments were made with the same quantities of the metals in the following combinations, $Co\,(NO_3)_2$ with $Ni\,SO_4$, $Ni\,(NO_3)_2$ and $Ni\,Cl_2$ $Co\,SO_4$ with $Ni\,(NO_3)_2$, $Ni\,SO_4$ and $Ni\,Cl_2$.

The results of these latter experiments were exactly the same as those of the first experiments, so that the Table does equally well to express them also.

If the cylinders, after the addition of the ammonium carbonate, be allowed to stand, the differences of tint disappear in a few hours, and a uniform deep purple red tint is produced. This is caused by the cobalt

absorbing oxygen from the air to form the double compounds of cobalt and ammonia. A small quantity of a sulphite destroys the reaction, as it changes the tint to a deep brown. Thiosulphates and some other reducing agents do not act in this way.

These experiments lead to the conclusion that the colour coefficient of nickel with regard to cobalt is 3·16, in all cases, or, in other words, that the tint of nickel and cobalt solutions is independent of the acid radical in combination with the metals, and depends only upon the metal in solution. It is evident that nickel and cobalt may be estimated by means of this reaction. As an example of its application to this purpose, I give the following account of the manner in which small quantities of nickel may be estimated.

The nickel must be dissolved in an acid, and the solution diluted to any convenient quantity, *e. g.*, 50 or 100 cubic centimetres. Into each of three cylinders ·0078125 grm. of Co as $Co\,Cl_2$ is placed. This amount of cobalt is afforded by 6·25 c. c. of the standard $Co\,Cl_2$ solution. Calling the cylinders No. 1, No. 2, and No. 3, we place in No. 1, ·024531 grm. of nickel in solution, and in No. 3, ·0248458 grm. To the three cylinders we then add 25 c. c. of the standard ammonium carbonate. Cylinder No. 2, which contains only cobalt solution and ammonium carbonate, is then made up nearly to 150 c. c., and No. 1 and No. 3 are filled up to that quantity. Cylinder No. 1 has then a purple tinge, while cylinder No. 3 has a blue tinge. By adding from a burette the solution whose strength we wish to determine to No. 2, until its tint is intermediate between No. 1 and No. 3, we make with great accuracy the required determination. In all cases the cylinders should be held, whilst under comparison, with their lower extremities at some inches distance above a sheet of white paper. Three experiments, that by no means reached the highest limit of accuracy, gave the following results :—

Ni in solution.		Ni found.
·02469 grm.	(1)	·02425
	(2)	·02475
	(3)	·02500
		·02466 = mean.

It is evident that a similar plan of estimating cobalt would be still more accurate on account of the higher colour efficiency of that metal.

The partially opaque brown solution obtained by mixing *strong* solutions of nickel and cobalt might, I think, be used for making standards for the purposes of colorimetrical analysis. For instance, the brown solution mixed with a few drops of potassic bichromate cannot be distinguished from Nesslerised ammonia. Probably the tests used to compare the solutions of steel, in Eggertz's process for the estimation of carbon, might be made in a similar manner. They would have the advantage of being permanent.

XXII.—ON SCHUTZENBERGER'S PROCESS FOR THE VOLUMETRIC ESTIMATION OF OXYGEN IN WATER. By CHRISTOPHER CLARKE HUTCHINSON, Royal Exhibitioner, Royal College of Science.

[Read, December 10, 1877.]

IN judging of the character of a water for domestic uses, one of the most important points to be ascertained is, the question of its pollution by sewage and other deleterious matters.

The determination of this pollution, its extent and nature, is at present rather unsettled. It is, however, believed by many chemists that a contamination, such as referred to, will exercise an effect upon the gaseous bodies held in solution in a water. It is the opinion of many, that the relative quantity of oxygen present in a water affords the key to its deterioration by organic matter; because it is unlikely that a large quantity of oxygen can be held in solution by a water containing oxidizable matter. Waters which contain their normal proportion of oxygen, in relation to their other gaseous constituents, would be regarded as free from sewage and decaying matter; a diminution in the quantity of oxygen would indicate a corresponding increase in the amount of injurious matter present.

The late Dr. Miller's analyses of the gases present in the water of the Thames, at various points, clearly proved that as the amount of sewage *increased*, the amount of carbonic acid increased, and the amount of oxygen *decreased*.

The Rivers' Pollution Commissioners state in their sixth Report that the proportion of oxygen in water is deprived of much importance, since it has been discovered that deep well waters, which cannot contain putrescent organic matter, contain little or no dissolved oxygen. The absence of oxygen in deep well waters may, however, be owing to its having oxidized and destroyed the organic matter the water previously contained, during its percolation through the strata.

In the presence of this conflicting testimony, I was induced to undertake an investigation, in the hope of throwing some light upon this important question—whether or not the amount of oxygen present is, or is not, an indication of the freedom of a water from injurious organic bodies.

In commencing the inquiry I was desirous of employing some accurate, and yet rapid, method, for the estimation of the oxygen present; for although the gasometric operations by Bunsen's method leave nothing to be desired in point of accuracy, yet on account of their somewhat tedious nature some other plan, if even slightly less accurate, but at the same time more rapid, would be desirable.

Such a method as this I thought might be afforded by the process devised by Schutzenberger for the volumetric estimation of oxygen in

oxygenated liquids.[1] As the estimation is made without the removal of the oxygen by boiling, and in the condition in which it exists in the water, such a plan would seem to be more desirable than its expulsion from the liquid, together with the other gases held in solution, and their subsequent determination.

I now proceed to give the results I have obtained by means of this volumetric process.

Briefly described, the method consists in adding a known volume of the water under experiment to a solution which is capable of being oxidized (accompanied by a change of colour due to such oxidation) by the oxygen held in solution. The extent to which this has occurred is then determined, by the addition of a powerful reducing agent, which, acting upon the coloured compound so formed, reduces it to its former condition—the amount necessary being, of course, indicated by the reverse change of colour to that which occurred in the first instance. This last solution being standardized in terms of the oxygen it is capable of taking up, from the amount used in the experiment we arrive at the volume of oxygen contained in the volume of water taken.

The re-agents used I will now describe, with the method, and proportions for their preparation I found most advantageous.

The reducing agent used is sodium hyposulphite—not the commonly so-called "hyposulphite," but the sodium salt of the acid $H_2 SO_2$; its formula as given by Schutzenberger is $Na H SO_2$. I prepared this as follows:—A concentrated solution of caustic soda ($Na HO$), specific gravity 1·4, was taken; sulphurous anhydride (SO_2) was passed through it, until the liquid was thoroughly saturated, and smelt strongly of the gas. The yellow liquid (which was kept cool during the process of saturation by immersion in cold water) is sodium bisulphite ($Na H SO_3$); it increased slightly in bulk, and was reduced to the specific gravity of about 1·34. 100 grammes (75 cub. cents.) of this solution was then briskly agitated in a flask with 6 grammes of powdered zinc, air being excluded; an elevation of temperature occurred, the bisulphite being converted partly into the hyposulphite, together with the formation of sodium sulphite and zincic sulphite, according to the following equation:

$$3 Na H SO_3 + Zn = Na H SO_2 + Na_2 SO_3 + Zn SO_3 + H_2O.$$

After agitation for about five minutes, the liquid was allowed to cool; 400 cub. cents. of water recently boiled were added; 35 cub. cents. of milk of lime, containing 200 grammes of CaO per litre, were also added, and the mixture allowed to stand until clear, when it was decanted off into well-stoppered bottles, and kept in the dark. The lime solution not only precipitates the zinc salt, but also

[1] *Bulletin de Chemie et Physique*, vol. xx.

renders the solution less absorbent of free oxygen, although it acts very rapidly upon dissolved oxygen. Before use this was further diluted with three times its bulk of distilled water, recently boiled.

The liquid recommended by which the change of colour detects the completion of the process is either carmine indigo (sulphindigotate of soda, $C_8 H_4 Na NOSO_3$), or Coupier's aniline blue. 10 grammes of the carmine indigo are recommended to be dissolved in one litre of water, the product being kept in well-stoppered bottles also in the dark.

An ammoniacal solution of pure copper sulphate is also recommended to be made, containing 4·46 grammes (or, more correctly, 4·471 grammes) of the crystallized salt per litre. This is to be used for the standardization of the above two solutions.

Since the reducing agent is so sensitive to the presence of oxygen, it is necessary to make the estimations in an atmosphere of pure hydrogen. To ensure the purity of the hydrogen, I passed it through a solution of nitrate of silver, in addition to the sulphuric acid, and the tube containing pieces of caustic potash.

We begin by finding the volume relation between the indigo and hyposulphite. The burettes of the apparatus are filled, one with indigo carmine solution, the other with hyposulphite; a rapid current of hydrogen is passed through the apparatus, a small quantity of warm distilled water added, and this coloured by the addition of a small quantity of indigo. We now add cautiously the hyposulphite; the blue solution turns first green, and finally to a clear yellow tint. If the whole of the air has been expelled from the apparatus, the yellow tint will remain unchanged; the slightest trace of oxygen causes the surface of the liquid to become blue. A known volume of indigo (25 cub. cents.) is now added, and the hyposulphite solution again run in until the yellow tint appears, indicative of the reduction of the whole of the indigo. The colour change is exceedingly sharp, one drop being sufficient to change the colour from green to yellow. If the solution be acid, the blue colour changes first to red, and finally the yellow tint appears.

We next require to find the reducing power of the hyposulphite in terms of oxygen, finding from this the amount of oxygen any volume of the indigo will yield. This being a stable solution, the hyposulphite (being liable to change) can be readily standardized at any future time.

Two methods can be used, by which this reducing power can be found:

First. By finding the quantity necessary to reduce the ammonia copper solution, *i.e.*, the amount which brings the blue solution to a colourless state, by the reduction of the cupric to cuprous oxide, 10 cub. cents. of this solution yields 1 cub. cent. of oxygen (0°C. 760 m.m.s. pres.) to the reducer. 25 cub. cents. are operated on in a smaller apparatus, similar to the one used for the water estimations. I find, however, that the colour change in this plan is so inde-

finite, and difficult, even to the practised eye, to detect, that the exact point cannot be determined with any degree of certainty.

The second method consists in obtaining a pure water saturated with air, and then finding the quantity of hyposulphite capable of abstracting the whole of its oxygen.

This water is obtained by agitating in a large flask about one litre of distilled water with free access of air; the agitation is continued for about a quarter of an hour. To find the amount of oxygen in a given volume of the water, I made the following formula, from the consideration of the relative quantity of oxygen present in the air, and its coefficient of absorption in water:

$$v = 0{\cdot}0262 \times a_{t^\circ} \times V \times \frac{P}{95},$$

in which we have

v = vol. of oxygen in cub. cents. at 0° C. and 760 m.m.s. pres.

a_{t° = coefficient of absorption of oxygen in water at temp. t° C., given by Bunsen's Tables.

V = volume of water employed, temp. t° C.

P = barometric pressure in m.m.s.

The relation between the saturated water and the hyposulphite is found in exactly the same way as the method, hereafter described, for the oxygen determination in waters. I found that, although the hyposulphite solution was about the strength recommended, the volume relation between it and the indigo, instead of being one to ten, was equal. As the indigo solution thus appeared ten times too concentrated, I further diluted it for use.

The following is an example of standardization by the above method. The apparatus was in every way regulated as described for water estimations:—

Comparison of Hyposulphite and Indigo.

Mean of five experiments gave

25 cub. cents. indigo = 7 cub. cents. hyposulphite.

Comparison of Saturated Water and Hyposulphite.

Mean of five experiments gave

75 cub. cents. of water = 2·4 cub. cents. hyposulphite,

from which is found

25 cub. cents. indigo = 218·75 cub. cents. of water.

temperature of water = 12·6° C.

barometric pressure = 744 m.m.s.

We therefore have

$$v = 0{\cdot}0262 \times 0{\cdot}031024 \times 218{\cdot}75 \times \frac{744}{95} = 1{\cdot}392\,;$$

therefore

25 cub. cents. indigo = 1·392 cub. cents. oxygen.

I made determinations on different days, at different conditions of temperature and pressure. The following shows the quantity of oxygen 25 cub. cents. of indigo was calculated to yield in each case:

$$\left.\begin{array}{l}\text{Temp. } 12{\cdot}6^\circ\text{ C.}\\ \text{Pressure, } 744\text{ m.m.s.}\end{array}\right\} = 1{\cdot}392\text{ cub. cents.}$$

$$\left.\begin{array}{l}\text{Temp. } 15{\cdot}5^\circ\text{ C.}\\ \text{Pressure, } 771\text{ m.m.s.}\end{array}\right\} = 1{\cdot}448\ \ ,,\ \ ,,$$

$$\left.\begin{array}{l}\text{Temp. } 14{\cdot}75^\circ\text{ C.}\\ \text{Pressure, } 752\text{ m.m.s.}\end{array}\right\} = 1{\cdot}354\ \ ,,\ \ ,,$$

Mean, ... = 1·398.

The small amount of variation, under widely different conditions, shows this method of standardization to be a reliable one.

I now proceed to give the method for the estimation of oxygen contained in a water. Owing to the change which the hyposulphite undergoes, it is necessary that a comparison between it and the indigo should be made each day. After this has been done, and the apparatus freed from air by means of the hydrogen, 200 cub. cents. of warm water (temp. about 50° C.) are then added; 50 cub. cents. of indigo are now run in. This I usually effected in portions of about 15 cub. cents. at a time, decolourizing each portion by means of the hyposulphite, thus utilizing this step for the comparison of the two re-agents; effecting thereby a saving of time and material. The liquid in the apparatus being now brought to the yellow neutral tint, a measured volume of the water under experiment is added—75 cub. cents. I found a convenient quantity—taking care that no air is admitted at the same time. The bleached indigo will now become re-oxidised, turning from yellow to blue, in proportion to the amount of oxygen present in the water. The hyposulphite is now cautiously added, until we again arrive at the yellow tint, free from green; a single drop of the re-agent is sufficient to effect the colour change at the proper point. From the quantity used, we find the amount of oxygen present in this 75 cub. cents. of water. The operation can be repeated over again on

another volume of the water, until the apparatus becomes inconveniently full. I usually made from four to six such experiments in each case. The temperature of the apparatus must be kept at about 50° C., by the addition of warm water at intervals; the amount of hyposulphite required becomes gradually less as the apparatus cools, giving the results too low.

To test the accuracy of the method, I took a measured volume of the same water at the time of the experiments, expelled the gases by boiling, collected this gaseous mixture, and determined its volume and composition by the usual methods of Bunsen's gasometric analysis.

The following examples are taken, to illustrate the method of analysis.

Volumetric Method.

Mean of four determinations gave

25 cub. cents. indigo = 8·21 cub. cents. hyposulphite.

This quantity of indigo we before found to yield 1·398 cub. cents. of oxygen. Therefore

8·21 cub. cents. hyposulphite = 1·398 cub. cents. of oxygen.

Mean of five determinations gave

3·55 cub. cents. hyposulphite = 75 cub. cents. of water.

From this we find the quantity of oxygen contained in 2·420 litres of water—the volume used in the gasometric method.

2·420 litres of water contain 19·505 cub. cents. of oxygen.

Gasometric Method.

Volume used, ... 2·420 litres.
Temperature of water, . . . 13° C.

	Volume.	Temperature in o° C.	Pressure in m. m. s.	Column of Mercury above that in trough, in m. m. s.	Corrected Volume at o° C. and 760 m. m. s. pres.
Total vol. of Gas evolved, .	302·56	13·9	737	268·8	237·719
After absorption of CO_2, .	316·149	14·9	745	229·2	193·959
After the admission of H, .	503·6	14·4	765	55·2	439·066
After explosion, ...	325·96	12·4	771	230·5	217·337

Percentage Volume Composition.

Carbonic acid, ...	18·408
Oxygen, ...	31·091
Nitrogen, ...	50·500
Total, ...	99·999

Absolute Volume Composition in Cub. Cents.

Carbonic acid, ...	10·238
Oxygen, ...	17·294
Nitrogen, ...	28·087
Total, ...	55·619

	Cub. Cents.
Volume of oxygen by Volumetric method,	19·505
,, ,, ,, Gasometric ,,	17·294
Excess given by Volumetric method,	2·211

Other samples from the same source were also experimented upon, the results being variable.

Water of a different character to this last was also experimented upon, with the following result:—

Volumetric Method.

Mean of three determinations gave

25 cub. cents. indigo = 7·25 cub. cents. hyposulphite;

therefore

7·25 cub. cents. hyposulphite = 1·398 cub. cents. oxygen.

Mean of four determinations gave

3·42 cub. cents. hyposulphite = 75 cub. cents. water.

From this we find

2·420 litres of water contain 12·486 cub. cents. of oxygen.

Gasometric Method.

Volume used, ... 2·420 litres.
Temperature of water, ... 11° C.

	Volume.	Temperature in 0° C.	Pressure in m.m.s.	Column of Mercury above that in trough, in m.m.s.	Corrected Volume at 0° C. and 760 m.m.s. pres.
Total vol. of Gas evolved, .	612·73	8·4	736·5	211·8	403·95
Gas used, ...	369·04	8·4	736·5	211·8	243·294
After absorption of CO_2, .	240·16	8·8	729·5	327·5	123·063
After admission of H, . .	364·97	8·8	729·5	187·5	253·313
After explosion, ...	261·2	8·7	729·5	296	141·584

Percentage Composition.

Carbonic acid, ... 49·418
Oxygen, ... 15·308
Nitrogen, ... 35·274

Total, ... 100·000

Absolute Volume Composition in Cub. Cents.

Carbonic acid, ... 46·715
Oxygen, ... 14·471
Nitrogen, ... 33·343

Total, ... 94·529

Volume of oxygen by Volumetric method, 12·486
,, ,, ,, Gasometric ,, , 14·471

Difference, ... 1·985

In this case the Volumetric method shows a *less* volume of oxygen than the Gasometric method. This, I think, is attributable to the

large quantity of carbonic acid present; for, as Schutzenberger points out, when an acid is present in appreciable quantity, even such a weak acid as carbonic acid, the results given are invariably too low; hence this method would not be applicable, with any degree of accuracy, to waters in which a large quantity of carbonic acid is present.

I made numerous determinations, from which the two foregoing examples are selected; but none of them showed any trustworthy results; in some cases the volume of oxygen obtained being in excess, and in others less than that obtained by the Gasometric method.

The variability of the results led me to inquire into the source of these discrepancies, and how they might be avoided.

Noticing that a change of colour in the yellow neutral tint seemed to occur to a greater extent than it should do on the addition of recently boiled distilled water, I made the following experiments.

Distilled water was boiled in a flask fitted with a cork and exit valve so as to avoid contact with air, for over four hours. The apparatus was prepared as usual with indigo and hyposulphite, the temperature being kept at 50° C. The boiled water, which was kept in well-stoppered bottles, was then added in successive portions of 75 cub. cents. at a temperature of 55° C. On each addition a blue colouration was produced in the yellow neutral liquid, just as if oxygen had been absorbed by the reduced indigo. The amount of colour change was determined as usual by the addition of hyposulphite. The mean of five experiments showed that 2·9 cub. cents. were necessary to bring back the yellow tint. This quantity was found to be equivalent to 3·86 cub. cents. of indigo, or 0·201 cub. cents. of oxygen.

Unwilling to think that this was due to oxygen which had been left unexpelled by ebullition, I boiled recently-distilled water in long-necked flasks, fitted with corks and exit valves, for over five hours. The apparatus was prepared as usual, but in this case water at 100° C. was used, and the body of the apparatus immersed in water kept at 100° C. Portions of 75 cub. cents. of water were removed from the flasks whilst in a state of ebullition, and introduced into the apparatus; each addition caused a change of colour from yellow to blue. The mean of five experiments showed that 1·25 cub. cents. of hyposulphite was necessary to destroy the colour.

1·25 cub. cents. hyposulphite = 1·66 cub. cents. indigo = 0·08 cub. cents. of oxygen.

After boiling for over six hours, the water was allowed to cool, out of contact with the air, and in withdrawing portions from it coal gas was aspirated in, instead of air, so as to avoid as far as possible contact with oxygen.

The same experiments were tried at the ordinary temperature (16·75° C.), and the same volume of water (75 cub. cents.) used. The mean of four experiments gave the colour change equivalent to 1·3 cub. cents. of hyposulphite = 1·56 cub. cents. of indigo, or 0·087 cub. cents. of oxygen.

The same experiments were now made at the temperature 0°C., by

cooling the boiled water previous to its addition, and immersing the apparatus in a bath cooled by a mixture of ice and salt. The results in this case were variable, the introduction of 75 cub. cents. of water requiring from 0·9 to 2·4 of the hyposulphite. I found this to be due to the length of time the apparatus was allowed to stand in the bath, after the introduction of the water. The longer the time, the less the quantity of the re-agent required to destroy the blue tint produced. To make certain that such a change did occur, I brought the liquid to the yellow tint, and then added a few drops of indigo, so as to produce a distinct green colour. On allowing the apparatus to stand in the bath, this gradually disappeared. I tried this several times, adding variable quantities of indigo in excess; but in all cases (within certain limits), when allowed to stand in the cold water, the green colour was gradually replaced by the yellow tint, just as if a quantity of hyposulphite had been added.

I attempted to remove these errors by a modification in the method of procedure.

The burette used for the indigo was replaced by a larger one (100 cub. cents. capacity). After placing in the apparatus a quantity of indigo solution, expelling the air, and bringing to the neutral point as usual, a known excess of the hyposulphite was added. Saturated water, as before described, was then added from the large burette, so as to oxidize the excess of hyposulphite, and just tinge the liquid green. From the volume required, by using the formula before given, the volume of oxygen contained in this can be found; hence the equivalence of the excess of hyposulphite in terms of oxygen. The same operation is performed with the water under experiment acting upon the same excess of hyposulphite. The relation between the volume used and that of the saturated water gives the amount of oxygen in the liquid. Any errors resulting from change in the solution would thus be eliminated, and the calculations simplified. On trying this method, I did not find the results any more satisfactory than the original method, although performed with the greatest care: they gave quantities in excess of that given by the Gasometric method. Thus, in 2·420 litres of water,

	Cub. Cents.
Volumetric modification gave, ...	15·133
Gasometric method, ...	12·650
Excess, ...	2·483

Although this Volumetric method possesses the great merit of exceeding rapidity, yet the many precautions necessary to be taken greatly detracts from the value and reliability of the results. It seems to be better suited for the determination of oxygen in small rather than in large quantities of a liquid, such as are desirable in water estimations. It is also valuable as a means of showing whether it would be desirable to estimate the amount of oxygen present in a water, by the more

accurate methods. The process adopted by Schutzenberger for checking the results appears to have been, submitting the liquid to the action of the mercury pump for fifteen or twenty minutes. I do not think this is sufficient, for, in expelling the mixed gases from a water by boiling, I have found that traces of gas are given off even after a considerable period.

One great drawback is the considerable amount of change the hyposulphite solution undergoes, even when excluded from the air and kept in the dark. The following give the volume ratios between it and the indigo, as taken on different days, showing the extent of this change:—

Oct.	23rd.—25	cub.	cents.	indigo	= 7	cub.	cents.	hyposulphite.
,,	25th.—25	,,	,,	,,	= 7·84	,,	,,	,,
,,	27th.—25	,,	,,	,,	= 9·8	,,	,,	,,
Nov.	1st.—25	,,	,,	,,	= 13	,,	,,	,,
,,	6th.—25	,,	,,	,,	= 20·75	,,	,,	,,

These investigations were carried out in the Chemical Laboratories of the Royal College of Science, under the supervision of Professor Galloway.

XXIII.—Further Researches on the supposed Substitution of Zinc for Magnesium in Minerals.[1] By Edward T. Hardman, F.C.S., &c., Geological Survey of Ireland.

[Read, February 25, 1878.]

Some time ago, during the analysis of chalk from the county Tyrone, I noticed that the specimens examined contained traces of zinc, and I also found that metal in small quantity in the overlying basalts. It subsequently occurred to me that, owing to its marked relations in physical and chemical characters to magnesium, zinc might be expected to occur in rocks or minerals containing compounds of the latter metal. Accordingly, I made some analyses of such magnesium minerals as I had at hand, and the results, which fully equalled my expectations, were laid before this Academy, and printed in the *Proceedings* for 1874. Those analyses comprised some eight or ten rocks or minerals characterised by magnesian compounds. Since then, in the intervals of other chemical research, I have continued this investigation, and in nearly every instance I have obtained small quantities of zinc combined in these magnesian rocks or minerals, and also in a few cases in minerals of the metals belonging to the same isomorphous groups as zinc and magnesium—for instance, in iron pyrites, and in limestone, in which there was little or no magnesia. I give below a list of twenty different specimens from various places, in all of which zinc is unmistakeably present, and often in very appreciable quantity.

Method of Analysis.—In all but one or two cases the analysis was twofold. First, an examination with the blowpipe was made, and then if zinc was indicated, a complete analysis in the wet way. In many instances the blowpipe results were so strongly marked, and so unmistakeably showed the presence of zinc, that a wet analysis was really superfluous. But to put the matter beyond all question, it was performed on a sufficiently large quantity of the rock or mineral.

For details as to the analytical methods adopted, I shall only refer to my former Papers on this subject, where they are given fully. There is one point worth mentioning, however, in this connexion. It appears to be usually the impression that the only reliable blowpipe tests for zinc are the white incrustation, and the green colour imparted by nitrate of cobalt; and that it is too volatile to be reduced to the metallic state on charcoal. Such appears to be the idea on which are based the directions for its detection, in many books on Chemical Analysis, or special works on the Blowpipe, but it is an erroneous

[1] See "Analysis of Chalk, County Tyrone, with Note on the Occurrence of Zinc therein," *Journal Royal Geological Society of Ireland*, vol. iii., p. 159. Also *Geological Magazine*, vol. x., p. 434; and "On a supposed Substitution of Zinc for Magnesium in Minerals," *Proceedings Royal Irish Academy*, vol. i. Ser. 2 (Science), p. 534.

one, for with care the metal is easily reducible. With less than half a grain of mineral, containing a mere trace of zinc, fused on one of Griffin's reduction pastiles, I have obtained sufficient of the metal to apply the most characteristic wet tests, and such as could leave no doubt as to the nature of it; while with large capsules, and a properly managed reducing flame, the feat is perfectly easy with larger quantities.

The following list gives the principal specimens in which I have found zinc:—

(1). *Talc Schist* from the sea shore, Mullaghglass, county Galway,[2] containing large, well-defined hornblende crystals. The blowpipe analysis gave strong indications of zinc. This was confirmed by a wet analysis, which showed the presence of zinc in appreciable quantity. Small quantities of copper, silver, lead, and nickel were also present.

(2). *Hornblende.*—The crystals from the above also contained zinc.

(3). *Dark-green Serpentine* from N. slope of Croagh Patrick Mountain, county Mayo, contains considerable traces of zinc; also copper, and a small quantity of nickel, quite enough for estimation. This fact deserves particular notice, since it is the only serpentine in this country, as far as I am aware, in which nickel has yet been observed. Doubtless it is of not unfrequent occurrence in such rocks, but Dana's lists of analysis only mention a few localities, most of which are American.[3] It might be expected also to occur in magnesian rocks, its compounds being isomorphous with the corresponding ones of magnesium and zinc; and, in fact, I have often met with it in such rocks, but never in such large quantity as in this specimen.

(4). *Flesh-coloured Dolomite* from the carboniferous limestone of Ballyfoyle, near Kilkenny. The blowpipe showed zinc to be present, which was confirmed fully by a wet analysis. Small quantities of copper and lead were also present.

(5). *Dolomite* from Ballyfoyle, similar to above. Presence of zinc shown by blowpipe and wet analysis. In both these in small quantity for magnesian rocks.

(6). *Dolomite* from Clara, near Kilkenny, similar to the above; extremely friable, contains crystals of calcspar; blowpipe examination proved the presence of both zinc and lead. Two wet analyses confirmed this, and showed the zinc to exist in estimatable quantity.

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[2] For this and other Galway and Mayo specimens I am indebted to my colleague Mr. G. H. Kinahan, M. R. I. A. For several others, to my colleagues Mr. Nolan, M. R. I. A., and Mr. Henry.

[3] Since writing this I find it has been noticed in the black serpentine of the Lizard. See Rev. T. G. Bonney, M. A., and W. H. Hudleston, Esq., M. A., "On the Serpentine and Associated Rocks of the Lizard District," *Journal Geological Society of London*, 1877, p. 925. Mr. Kinahan informs me that nickeliferous pyrrhotite occurs in veins in the old beds of the Croagh Patrick district. The age of their veins is, however, not certain.

(7). *Very compact Crystalline Magnesian Limestone* from Tawnagh, Toormakeady, county Mayo. Associated with upper Silurian rocks and bedded igneous rocks. The blowpipe and subsequent wet analysis showed the presence of zinc in small quantity.

(8). *Hornblende Schist* from Inish-gloria Island, Belmullet, county Mayo, gave small traces of zinc.

(9). *Hornblende Rock* from Annagh Head, Belmullet. Blowpipe examination proved this to contain zinc in very appreciable quantity, confirmed by subsequent wet analysis. A little copper present.

(10). *Very pure Talc* from county Galway. The blowpipe showed considerable traces of zinc, and some of lead. Zinc very distinct.

(11). *Black Mica* from a vein in the summit of Liss-oughter, county Galway. The blowpipe gave the usual indications of zinc *very distinctly*. Quite a number of spangles of zinc were reduced. Wet analysis confirmed its presence. Traces of copper and lead were also observed.

(12). *Orthoclase Felspar* from a felstone porphyry, county Mayo. The blowpipe gave faint indications of zinc. On reduction, a few tiny spangles were obtained, which gave the usual zinc reactions. The very small quantity of zinc present is thoroughly consistent with the theory of its connexion with magnesium, since orthoclase contains usually a very trifling amount of that metal.

(13). *Hornblendic Epidotic Rock* containing numerous radiated nests of *Actinolite* or *Tremolite*, from Cannaver Island, Lough Corrib. This rock is described by Mr. Kinahan as passing into serpentine rocks.[4] The *actinolite* is almost infusible, and appears to be a highly magnesian variety. With the blowpipe it gave abundant indications of zinc. The mineral reduced with carbonate of soda yielded a large quantity of spangles of metal easily soluble with evolution of hydrogen, in dilute hydrochloric acid. A wet analysis fully confirmed this. Traces of copper and lead were also observed.

(14). *A Serpentine Rock* from N. W. slope of Croagh Patrick, county Mayo. In a compact base contains crystals of hornblende, and layers of fibrous serpentine. The fibrous serpentine, reduced with carbonate of soda, gave numerous spangles of zinc, which afforded the usual zincic reactions.

(15). *Chlorite* from a granite from Limehill, near Pomeroy, county Tyrone. Traces of zinc very distinct.

(16). *A dark graphitoidal steatitic Argillite* from county Mayo. Examined with blowpipe. Indications of zinc distinct.

(17). *Very pure greenish Steatite* from county Mayo. The blowpipe analysis of this yielded a large indication of zinc and nickel; also traces of lead. This specimen contained an estimatable quantity of nickel; and in order to be certain of the presence of zinc, which was rendered

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[4] Ex. Mem Sheet 95, *Geological Survey, Ireland*, pp. 13 and 33.

difficult by the presence of the former metal, no less than four distinct wet analyses from different portions of the mineral were made. In all of these both nickel and zinc were present, the former somewhat abundantly.

(18). *Talc Rock* from Crohy Head, county Donegal. From Geological Survey Collection. A white or cream-coloured rock. The blowpipe examination proved in this the presence of zinc, together with small traces of copper and lead. A proof experiment with another portion of the mineral, boiled in strong hydrochloric acid, showed the zinc to be present in appreciable quantity.

(19). *Iron Pyrites.* The last mineral contains numerous small crystals of iron pyrites. These, examined in the usual way, yielded zinc. As I have already remarked, ferrous iron belongs to the magnesium group.

(20). *Actinolite Rock* from Cannaver Island, Lough Corrib. Similar to No. 13. Blowpipe analysis proved this to contain zinc in the same quantity as in No. 13.

(21). *Serpentine* from Liss-oughter, county Galway. With the blowpipe a remarkably distinct indication of zinc. The mineral, reduced with carbonate of soda, yielded quite enough metal for identification. Besides zinc, nickel is also present in some quantity, and there are traces of silver and tin.

What I wish to urge upon your attention, as the result of these investigations, is the almost invariable occurrence of zinc in the minerals examined. I have already shown that the presence of zinc as an accessory component of minerals has been almost entirely neglected—in fact it is only mentioned where it occurs in considerable quantity, as in Franklinite or Automolite; and so uncommon is it looked on as an accessory, that the only augite in which its presence had been recorded before I had commenced this research was dignified with a special name—Jeffersonite.[5]

When a metal not usually occurring in rocks in any large quantity is recorded, it is usually because it exceptionally occurs so abundantly that its presence cannot well be overlooked; and it is only in such cases that zinc has been hitherto observed. It appears, however, that, like many other substances, it only requires to be sought after; and that its presence is not simply accidental, but the result of the invariable chemical laws of affinity and isomorphism; and I submit that zinc is as much to be regarded as an almost constant associate of the magnesium group as indium and osmium with platinum; niobium with tantalum; rhuthenium and rhodium with palladium, and so on.

In all the instances I have noted in this and my former Paper, the quantity of zinc is small; but this again is really in favour of my view. Had the metal occurred in large quantity in portions of the

[5] Dana, *System of Mineralogy* (1873, p. 215).

rock, we should be entitled to consider its presence accidental; but its occurrence in small amount, and its being generally diffused in the rock or mineral, proves it to be truly a constituent.

A lode or thick deposit of zinc ore would be an accidental deposit; but it is from the infinitesimal quantities of this metal disseminated throughout rocks that workable accumulations are derived. As Bischof remarks, the minimum of a mineral in rocks becomes the maximum in lodes; and, although the small traces of zinc in the specimens given above may appear insignificant, it must be remembered that a knowledge of the fact of the diffusion of minute quantities of the metallic compounds through rocks leads to a correct notion of the formation of mineral veins, as otherwise we should be compelled to regard them as exotic productions, derived from unknown sources.

XXIV.—ON THE NEGATIVE PEDAL OF A CENTRAL CONIC. By JOHN C. MALET, M. A.

[Read, February 25, 1878.]

ABSTRACT.

HAVING in some preliminary investigations proved a certain property of circular cubic curves which I require for the direct object of my Paper, I then investigate directly the principal properties of the first negative pedal of a central conic from any point. Many of these properties I show are also true for a more general class of curves, viz.: unicursal sextics with six cusps: thus for any such curve the following properties are true:—

(1). The six cusps lie on a conic.
(2). The six cuspidal tangents touch a conic.
(3). The eight tangents at the four double points touch a conic.
(4). The six points of contact of the three double tangents lie on a conic.

I prove, however, many less general properties of the curve I consider, which I believe are worth noticing—for example:—

"If we take the first negative pedal of a central conic from any point on either axis, then the six tangents to the curve from the cusps, but distinct from the cuspidal tangents, all touch the same conic."

Again:—

"The sixteen tangents at the eight double points of the negative pedals, with respect to the origin of the conics

$$ax^2 + by^2 + 2gx + 2fy + c = 0,$$

and

$$bx^2 + ay^2 + 2gx + 2fy - c = 0,$$

all touch the same conic."

The last part of my Paper is occupied with the consideration of a curve which is the locus of the centre of a variable circle, which cuts orthogonally a given circle and touches a given curve. From the equation of this locus I prove that we may at once deduce the equations of the following curves:—

(1). The negative pedal of the given curve.
(2). The parallel of the given curve.
(3). The negative pedal of the parallel of the given curve.
(4). The locus of the centre of a variable circle which touches the curve and a fixed circle.

I conclude by showing that we can form the equations of the parallel *et cetera* of a surface in an analogous manner.

XXV.—On the Extraction of Iodine and Bromine from Kelp. By Robert Galloway, F. C. S., Professor of Chemistry in the Royal College of Science for Ireland.

[Read, April 8, 1878.]

Having had, some time ago, facilities for becoming completely acquainted with the manufacturing processes followed for the extraction of iodine, bromine, and the potash salts from kelp, I devoted a considerable portion of time to the study of this branch of manufacturing industry. It is one of the manufactures which ought to flourish in Ireland, owing to the large quantity of the raw material (sea-weed) which can be obtained in this country. I am sorry to have to state that there is now no kelp factory in Ireland; the only buyers of Irish kelp at the present time are the Scotch manufacturers.

The description in works on Chemistry, of the processes followed for the extraction of the kelp products, are very meagre in a manufacturing point of view, especially as regards the extraction of the two most valuable substances, iodine and bromine, and these two substances are the most difficult to extract with manufacturing success. The descriptions state that such and such processes are followed; but important details are altogether omitted, as, for instance, the conditions most suitable for carrying out the processes successfully, and the different precautions which ought to be observed.

Iodine was at one time a monopoly. The iodine manufacturers combined together not to sell this substance under a certain price; which, like almost all other monopolies, had the effect of impeding rather than of promoting improvement in this branch of manufacture. The monopoly exists, I believe, no longer: new sources of supply of the substances I have termed kelp products—iodine from the mother liquors obtained in refining the nitrate of soda in Peru, bromine and potassic chloride from the salt beds in Prussia—have not only extinguished it, but have also rendered necessary the adoption of superior and more economical methods in the extraction of these substances from kelp, for the continuance of kelp being employed as a raw material.

Many methods have been proposed for the extraction of the two metalloids, iodine and bromine, from the ash of sea-weed; but the only one, as far as I am aware, which has been followed in the United Kingdom, at least up to a very recent period, is the one ascribed to Wollaston. By this method they are set free from the metals with which they are combined by the addition of sulphuric acid and manganese peroxide to the mother liquor which remains after the extraction (of course as far as it is practicable) of potassic sulphate and chloride, and what are termed the kelp salts, which are a mixture of sodic sulphate, carbonate, and chloride.

The sulphuric acid is added for a twofold purpose: a portion is required for the decomposition of the alkaline sulphides, sulphites, and hyposulphites, present in the mother liquor; the other portion, along with the manganese oxide, liberates the iodine and bromine from their combinations. When the sulphur, which is set free from

the decomposition of the hyposulphites, has completely deposited, the clear liquid is drawn off into the iodine still, and the manganese peroxide is then added to it.

When this process first came into operation, bromine had not been discovered in the ash of sea-weed; even the late Dr. Anderson, in his well-known and often quoted analyses of the ash of sea-weed, does not give it as a constituent. New analytical investigations of the ash of the various sea plants are wanted; the plants ought to be carefully freed, before incineration, from all adhering salt water, so that the quantities of chlorine, bromine, and iodine they naturally contain might be correctly ascertained. The investigation would lead, most probably, to the discovery that there are, properly speaking, *bromine* as well as iodine producing plants.

The three metalloids are each liberated from their metallic combinations by the manganese peroxide and sulphuric acid, but owing to their different degrees of affinity for metals—chlorine having the strongest, and iodine the weakest affinity—the latter is the first set free; but it requires the greatest care and attention to prevent some portion of the other two from being set free at the same time. If this occurs, they enter into union with one another, forming volatile compounds which affect the eyes, and have a very pungent odour. The liberation of the bromine or chlorine, or both, during the extraction of the iodine may occur, for instance, from the manganese oxide becoming unequally diffused in the liquid; they will also be liberated if the temperature of the liquid becomes too high; and it appears to me highly probable that the influence of *mass* will also cause their liberation, especially when the quantity of iodine becomes, by volatilization, much decreased in quantity. That they are liberated to some extent during the distillation of the iodine is at once perceived by those who visit the still during the distillation, and who are acquainted with the properties of these compounds. I may here observe that the still-man judges whether at least an undue proportion of the other two are volatilizing by the colour of the vapour; if it is of a brownish or whitish colour he is aware he is losing iodine. When the distillation is finished, and the still head removed, the vapour which escapes from the still has always a violet colour, and some iodine always remains in the liquid; for if the distillation were continued until all the iodine had volatilized, there would be evolved along with it in the last stages one or both of the other metalloids in somewhat large proportions; and consequently there would be a loss instead of a gain in iodine. These are some of the imperfections and difficulties of Wollaston's process.

The extraction of bromine follows the extraction of iodine, the same process being adopted, and similar precautions have to be observed.

It is evident such a process is unsuitable for the extraction of valuable substances like iodine and bromine, and it may also be observed that the liquid from which they have been volatilized has to be thrown away, on account of the difficulty of utilizing it, although

it contains a large quantity of potash salts and all the sulphuric acid employed in the extraction; the money value of which is estimated to be nearly one-half of the whole cost for extracting all the products from the kelp.

Chlorine is the agent, out of the many proposed as substitutes for the manganese oxide and sulphuric acid, which I would recommend, but under conditions somewhat different from those I have seen described; this difference in the conditions would render the process more exact, and better results in every respect would be obtained. The kelp solution I would render neutral by the addition of sulphuric acid before adding an aqueous solution of chlorine; and as I have found by investigation that the kelp solution contains clay, and as this substance tends to render the solution viscid and unfavourable for crystallization, I would, before evaporating to obtain the last crop of potassic chloride, nearly neutralize the liquid so as to get rid of it. Although a little more acid would be consumed than if it were all added in the ulterior stage, the disadvantage would be more than compensated by the larger crop of crystals of potassic chloride which would be obtained, and the greater concentration of the liquid. After the extraction of the last crop of potassic chloride, I would neutralize the liquid exactly, and then place it in a graduated vessel; I would then add to a small measured portion of it some bisulphide of carbon, and finally some chlorine water from a graduated vessel, until the violet colour just disappeared. This is a process frequently employed for the estimation of iodine, and occupies only a minute or two. Having ascertained the exact quantity of chlorine water which decolourizes the iodine—that is, converts it into pentachloride of iodine—it would only remain to add to the larger measured quantity of the liquid containing the iodine one-sixth of the relative quantity of the chlorine water which was required on the smaller scale. The small portion of iodine which would remain dissolved in the liquid, owing to its slight solubility in water, I would remove either by bisulphide of carbon or benzol. After the removal of the iodine, I would treat the liquid with chlorine water, with similar precautions for the removal of the bromine; but as the compound of chlorine and bromine is a monochloride, one-half, and not one-sixth, as in the case of the iodine, of the relative quantity of chlorine water would have to be added to the larger measured portion of the liquid.

If, in any case, it should be found desirable not to precipitate the entire portion of the iodine and bromine with chlorine water, on account of rendering the liquid too dilute, a portion might first be precipitated by chlorine gas, and the remainder by means of chlorine water in the way I have described.

This method would not only be speedy but exact, for it would be the conversion of a quantitative analytical operation into a manufacturing process. After the removal of the bromine, the alkaline salts which remained in solution could be easily recovered.

It would be necessary to sublime the precipitated iodine.

XXVI.—ON A NEW CHEMICAL TEST FOR CARBOLIC ACID, AND ITS USEFUL APPLICATIONS. By EDMUND W. DAVY, A. M., M. D., Professor of Forensic Medicine, Royal College of Surgeons, Ireland.

[Read, May 13, 1878.]

I HAD the honour, a short time ago, of bringing under the notice of the Academy, and of publishing in these *Proceedings*,[1] a new and exceedingly delicate chemical test for alcohol which I had at the time discovered; and I pointed out some practical applications which might be made of that test.

I subsequently directed attention to some further useful objects which may be attained by the employment of that alcoholic test, which latter have appeared in the *London Pharmaceutical Journal* for last year. I have recently discovered that the reagent which I employed for the detection of alcohol in the test referred to, viz., a solution of molybdic acid or molybdic anhydride in strong sulphuric acid, is a very delicate test likewise for carbolic, or as it is otherwise termed, phenic acid, a substance which is now one of considerable industrial importance, admitting as it does of so many useful applications, and one for which it is desirable to have a ready and at the same time a delicate test, for the detection of its presence under different circumstances. I have observed that when a drop or two of a dilute aqueous solution of carbolic acid is brought in contact with a few drops of the molybdic solution stated, there is immediately produced a light-yellow or yellowish-brown tint, which, passing to a maroon or reddish-brown, soon develops a beautiful purple colouration, which latter remains without further change for a considerable time. I should here observe that the application of a gentle heat will hasten the development of the purple reaction, though it will take place, but more slowly, at the ordinary temperature; and it is the production of this purple under the circumstances stated that constitutes the test for carbolic acid. The molybdic solution which I have chiefly used for this purpose is similar to the one I have employed for the detection of alcohol, and is made by dissolving, with the assistance of a gentle heat, one part of molybdic acid in ten parts by weight of pure and concentrated sulphuric acid. But the exact amount of molybdic acid dissolved appears to be a matter of indifference, as I have used other proportions with success, and in some recent experiments I found that a solution where there was only one part of molybdic acid in a hundred parts of sulphuric acid acted very well.

The mode of using this reagent is simply to add three or four drops of it to one or two of the liquid under examination, placed on any white porcelain or delf surface, when the effects already noticed will be produced, if carbolic acid is present. In carrying out this test, it will, however, be found the most convenient to use a small white porce-

[1] *Proceedings*, Second Series, vol. ii., Science, p. 579.

lain capsule, furnished with a handle, which will admit of the application of heat when it may be desirable to hasten the reaction by that agent.

This test is one of great delicacy, for I have found that one small drop of an aqueous solution of carbolic acid, containing a thousandth part of its weight of that acid, and only absolutely about the one-seventy-thousandth part of a grain, when mixed with three or four drops of the molybdic solution, produced immediately the yellowish-brown effect, which, after a few minutes, passed into a very distinct and beautiful purple colouration, and this colour remained quite perceptible on the fourth day afterwards, though it had each day become fainter from exposure to the air, and its consequent absorption of moisture. But this is not the limit of its delicacy, for I have detected by its means the carbolic acid in one drop of an aqueous solution five times more dilute, or where it contained the one-five-thousandth part of its weight of that acid, and in which there was only about the one-three-hundred-and-fifty-thousandth part of a grain present.

For the success of this test, it is necessary to attend to a few particulars, one of the most important being, that only a drop or two of the liquid under examination should be employed, for if much more be used the reagent will be diluted too much, and the characteristic reaction will not take place: for so great an effect has water on it, that even when the purple colouration is fully developed, the addition of that substance will cause either the colouration to disappear almost entirely, if the quantity of carbolic acid present be exceedingly minute, or if more abundant it first changes the purple to red, and then into a light reddish-brown, which becomes more and more faint on further dilution; but the addition of a few drops of the test solution, or even of strong sulphuric acid, again reproduces the purple, though of course fainter in its colour in proportion to the previous degree of dilution; thus showing that the mixture must be very strongly acid for the production and continuance of this purple effect. Another point to bear in mind is this, that when carbolic acid itself, and not an aqueous solution of it, is acted on by the molybdic reagent, a dark olive, quickly changing to a very deep blue, will be produced, but not the purple colouration; a cold saturated aqueous solution, however, of carbolic acid when so treated will yield the purple reaction; but even here there will be a tendency to develop the olive or blue effect, especially where the reagent employed contains a large proportion of molybdic acid; and I may observe that weaker solutions of carbolic acid give more satisfactory results, as the action appears to be too energetic when the acid itself or very strong solutions are employed.

The last precaution I wish to direct attention to, for the successful performance of the test, is this, that in applying heat to hasten the reaction, it should be limited to a gentle heat that the hand can bear when applied to the bottom of the capsule, this being about from 120° to 130° F., which is quite sufficient for this purpose, besides not exercising any destructive effect on the purple reaction; for I may observe that if the heat be raised even to 212° F., and con-

tinued for some time, the purple colouration will be destroyed and a blue produced; moreover, where organic matters are present along with the carbolic acid, many of them will likewise, when heated with the molybdic reagent to that latter temperature, or even much below it, develop a deep blue colour, which would mask more or less completely the purple effect of the carbolic acid. Consequently it is better in most cases to let the test act on the liquid at the ordinary temperature, though the reaction may be somewhat slower in developing itself.

I have made a number of comparative experiments with this test, and with the principal ones hitherto employed for the detection of carbolic acid, and I find, in point of delicacy, it seems only to be surpassed by the bromine test of Dr. Landolt, which depends on the circumstance that when an aqueous solution of bromine is brought in contact with carbolic acid, there is immediately formed the tribromophenol ($C_6H_3Br_3O$), a sparingly soluble white substance. But that test could not be successfully employed, at least immediately, in many cases, where the test just described might be still available, as for example, in the case of different organic mixtures, where the presence of the tribromophenol formed would be concealed. It possesses likewise the great advantage of being apparently not interfered with, to any extent, by the presence of organic substances which mask or prevent the reactions of many of the other tests.

As to what is the exact nature or composition of the purple compound which is formed in carrying out the test, I have not yet been able to determine, owing to the difficulty of isolating it, or of obtaining it in a condition suitable for analysis; but I am inclined to think that it is not so much an oxidation product of carbolic acid as a deoxidation one of molybdic acid, and that it is a combination of one of the oxides of molybdenum, containing perhaps more oxygen than the blue compound which is formed where the molybdic reagent acts on alcohol and on some other substances; and one circumstance amongst others which seems to support this view is this, that I have failed to obtain by the action of other oxidizing agents on carbolic acid a similar purple reaction.

Be this however as it may, I have satisfied myself that the purple compound formed in my test is a totally different substance from the red or crimson dye termed coralline, which is obtained by the united action of oxalic and sulphuric acids on carbolic acid, and is now largely used as a dyeing material; for the red colour of the latter substance is not affected by the caustic alkalies, and strong sulphuric acid changes it to a reddish yellow; whereas the purple developed in the new test is changed to green by caustic alkalies, and the purple again restored by strong sulphuric acid. I am, however, still engaged in this inquiry, and hope to be able yet to determine the exact nature of this purple compound, and of the changes which occur in this new reaction.

I shall now briefly notice some of the useful applications which may be made of this test. It is well known that carbolic acid is a

powerful poison, and many instances are now on record where it has been the cause of death, such being generally either cases of suicide, or those where it has been accidentally taken by mistake for some other substance; as its odour and taste would render its administration, at least to an adult, by the assassin for the criminal destruction of life, a matter of some difficulty. The occurrence, however, from time to time of the cases referred to obviously renders it very desirable to be able readily to detect the presence of carbolic acid where it has been so used, either in the articles of food, drink, or medicine which have been taken, or in the ejecta or contents of the stomach; and this test affords a very easy and ready means of so doing, and of confirming the indications of other tests. According to my observations it will detect the presence of carbolic acid in different complex organic mixtures, even where the odour of that substance may be quite imperceptible; and I may observe, that the test of odour has hitherto been regarded as the most delicate for carbolic acid in such cases.

The great advantage this test possesses, especially for such applications, is this, that it does not appear to be much affected or interfered with, as already stated, by the presence of a number of organic substances which are likely to be present in such cases. Thus, as regards different articles of food—I have readily detected, by means of this test, the presence of carbolic acid when a small quantity of its aqueous solution had been added to the following articles, viz.: tea and coffee mixed with sugar and milk, porter,[2] ale, wine, a solution of Liebig's extract of meat, and albumen; also where it had been added to blood, olive oil, gum, and soap—the very diverse substances in the articles mentioned not preventing the indications of the test.

It will also afford a ready means of detecting the elimination of carbolic acid in the urine, when that substance has been taken internally, for the compounds present in human urine naturally do not appear to affect to any extent this test. I may also observe, that with it I was at once able to detect the presence of carbolic acid naturally occurring in the urine of a cow, without any previous treatment of that secretion, and thus confirm the correctness of the statement as to the occurrence of that acid as a normal substance in the urinary secretion of that animal. This ready means of discovering carbolic acid in different animal fluids where it may exist will render this test useful to the physiologist and physician.

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[2] As alcohol acts on the molybdic solution producing an intense blue colouration, the presence of that substance, at least in any quantity, would mask more or less completely the reaction of carbolic acid. In examining, therefore, alcoholic liquors for that acid, it is better to submit them to distillation to separate the alcohol, and then to test the later portions of the distillate or the residue for carbolic acid; or what answers even still better in such cases is, to render the liquid alkaline by the addition of either caustic potash or soda, to combine with and fix the carbolic acid, and then distil; and when all the spirit has been removed, to add diluted sulphuric acid to slight acid reaction to liberate the carbolic acid, and after this distil again, when that acid will come over unmixed with any spirit, and give its characteristic reaction.

Another useful application of this test is, that it affords a very ready means of distinguishing creasote from carbolic acid, which is a matter of some commercial importance, much of what is sold as creasote being, as is well known to chemists and those in the drug trade, little else than carbolic acid; for these two substances, though obtained from different sources—true creasote being procured from the distillation of wood tar, whilst carbolic acid is got from that of coal tar—and though they differ likewise from each other in chemical composition, still so closely resemble each other in several of their properties, that the cheaper substance, impure carbolic acid, is in whole or in part frequently sold to the public for the dearer article creasote. If, however, we take a drop or two of each, and agitate them well with about a quarter of a fluid ounce of distilled water, and, having filtered the liquid, test a drop or two with the molybdic solution as already described, we will get in the case of pure creasote only a brown or reddish-brown reaction, which on standing or warming slightly becomes fainter, passing to a light-yellowish brown: whereas in the case of carbolic acid the brown passing to a maroon soon develops a more or less intense purple colour. This treatment will be sufficient to distinguish creasote from carbolic acid, and also to detect the presence of that acid in creasote, where it occurs in considerable proportion; for if, on the addition of the molybdic test solution, the mixture, instead of fading away to a light-yellowish brown on standing a short time, or on gently heating, passes to a reddish brown or to a maroon, it is an indication that carbolic acid is present. But I have found that the following very simple proceeding gave more satisfactory results, especially where small quantities of carbolic acid had been added to a large proportion of creasote. From five to ten drops of the liquid under examination are taken, and agitated briskly with about half an ounce of distilled water for a few minutes, so as to dissolve out the carbolic acid; the mixture is then filtered, and the filtrate is put into a little flask furnished with a close-fitting cork, through which passes a small glass tube about ten or twelve inches long, and bent above the cork at a little more than a right angle. The contents of the flask are then heated, and, when the liquid boils, the first portions which distil over will be found to present a more or less turbid appearance as they pass down the tube, from their containing minute globules of creasote; and a drop or two having been collected and tested with the molybdic reagent will give only the brown reaction of creasote: but by continuing the boiling, that substance will be more or less completely expelled, and then it will be found that a drop or two of the later portions of the liquid which distil over will give the purple reaction of carbolic acid. I may here observe that as it is only a drop or two of the distillate which is required each time for testing, it is not necessary to use any condensing arrangement, for the vapour passing through the tube itself is cooled sufficiently to furnish the small quantity required for each trial; but when it is desirable to collect in larger quantities the

different portions of the distillation, a very small Liebig's condenser, in which the delivery tube can be inserted, will be found the most convenient arrangement to employ. In this way, by distillation, I was enabled to detect the presence of carbolic acid in creasote, where I had mixed only one part of the former with a hundred parts of the latter, which would be more than sufficiently delicate for any case likely to occur in commerce; for where such adulteration was practised, it is probable that a much larger proportion of carbolic acid would be used, to render the fraud sufficiently remunerative. In the same way, I have readily succeeded in detecting the presence of carbolic acid in oil of cloves, where I had purposely added a small proportion of that acid, as it is stated that this very objectionable fraud is occasionally practised, of adulterating the essential oil of cloves with carbolic acid.

The few applications that I have referred to are, I should trust, sufficient to indicate the practical utility of this test; which, being at the same time so simple and easily performed, will, I have no doubt, be found useful for the objects stated, as well as for others to which it may be applied.

XXVII.—ON HULLITE, A HITHERTO UNDESCRIBED MINERAL; A HYDROUS SILICATE OF PECULIAR COMPOSITION, FROM CARNMONEY HILL, CO. ANTRIM, WITH ANALYSIS. By EDWARD T. HARDMAN, F. C. S., H. M. Geological Survey. With NOTES ON THE MICROSCOPICAL APPEARANCES, by Professor HULL, F. R. S.

[Read, June 24, 1878.]

PART I.

HAPPENING to visit Carnmoney Hill, near Belfast, during the Meeting of the British Association in 1874, I was much struck with the abundance in the basalt of a mineral which I had never before noticed in any of the basalts of the north of Ireland, and which I had reason to believe then, and still consider to be, somewhat new to Irish mineralogists, in so far that its composition and physical characters have not yet been described. It may have been observed before, but there is no description, at all agreeing with its characteristics, published.

The basalt in which this mineral occurs forms the old neck of a Miocene volcano. It is massively columnar, the columnar structure being, however, horizontal, not vertical, as is usually seen; but in all respects similar to what may be observed in large dykes or other masses of intrusive basalt. The rock itself is a rather coarse-grained dolerite; extremely vesicular and amygdaloidal, possesses a very high density, and is magnetic, affecting the needle very strongly—zeolites are not abundant, but the cavities are filled, or in some places only coated, with a peculiar black mineral which is the subject of the present notice.

In some cases this mineral entirely fills up the cavities, and throughout the rock it appears in great profusion; but in many places where the amygdaloids are only partially coated with it, the remaining space is filled with calcite—and occasionally apparently arragonite—for sometimes the crystals have a radiated structure which resembles that of a zeolite.

The black mineral from this locality has, I believe, never been hitherto described or analysed. On examining the maps of the Geological Survey I find the basalt is noted by the late Mr. Du Noyer as "black basalt, highly crystalline; cellular cavities lined with pitchstone," for which he evidently mistook this mineral. And in the Geological Survey collections in the Museum of the College of Science, Dublin, specimens from this place are labelled "Vesicular basalt, with obsidian." However, the peculiar softness of the mineral precludes this idea at once. There are two minerals to which it bears a distant resemblance. In physical characters it somewhat agrees with the chlorophæite of Macculloch, so far as colour, specific gravity, and hardness. But its chemical properties are totally different, as will be seen further on—that is, if we can rely upon the analyses of

that mineral by Macculloch and Forchammer, which give very extraordinary results. The presence of so called chlorophæite has been noted by Portlock[1] as occurring in the basalt of Down Hill (p. 227); Magilligan—abundantly in several beds exposed in the section there (p. 152–3), and at Carrick-a-rede, where the mineral imparts a porphyritic appearance to the rock (also at Craigahulliar, p. 154), and he mentions localities as Crosseagh and south Ballylagan where the trap, wanting the imbedded chlorophæite, has cavities occasionally lined with obsidian (p. 155)—this he mentions as occurring at the Giants' Causeway. Now it seems improbable that a highly acidic mineral such as obsidian would be found in basalt; and I am inclined to suppose that Portlock, as Mr. Du Noyer did afterwards, mistook the Carnmoney Hill mineral for obsidian.

Whether this Carnmoney Hill mineral is the same as that which Portlock calls chlorophæite I cannot say, as I have not seen specimens from the localities he names. But it is not at all clear that Portlock's so called chlorophæite is that of Macculloch, since analyses of it are wanting. If it be the same mineral as that I have examined, the composition is entirely different.

In chemical composition the mineral approaches more nearly to delessite. However, there are still very important differences, as will be seen on comparison. Delessite contains considerably less silica, more alumina, and more protoxides—lime especially being abundant. Again, the physical characters do not agree,—delessite is harder; its gravity is nearly $\frac{2}{5}$ more, its colour and streak different,—so that on the whole we must regard this mineral as a new one, although possibly belonging to the ferrugenous chlorite group.

Method of Analysis.—Separation of the mineral. This is so important a point that it may be well to devote a few lines to the description of the manner adopted. Although the mineral occurs most abundantly in very small nodules, it was found to be a most tedious process to extract sufficient of it even for a qualitative analysis. One method was to crush the rock—extract as much of the matrix as possible by means of a strong magnet, the small particles of magnetite, or perhaps native iron disseminated throughout it, rendering this possible, and collecting the mineral bit by bit with a forceps from the felspar and augite which remained behind. This, however, promised to be an endless proceeding—but I fortunately at the time happened to meet with a notice of the use of Sonstadt's solution for that purpose;[2] this I tried, and it succeeded so admirably that, although I have already noticed the result elsewhere,[3] a short description of the process may not be out of place here, as it is a matter that cannot be too well known to mineralogists.

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[1] *Geological Report on Londonderry, Antrim, &c.*
[2] Prof. Church, *English Mechanic*, January, 1878.
[3] "On the applicability of Sonstadt's solution to the separation of minerals for chemical analyses."—*Chemical News*, April, 1878.

Sonstadt's solution is a solution of mercuric iodide (or red iodide) in potassic iodide—the liquid being concentrated by adding, alternately, the mercuric and the potassic iodides until no more of either is taken up. Carefully proceeding in this way, a clear liquid can be obtained, having a specific gravity of a little over 3·00, according to Sonstadt and Church. It is clear that any mineral of less specific gravity than 3· floats on such a liquid, while any of higher gravity of course will sink; by diluting the liquid we can obtain a range of solutions capable of separating any minerals between 1·0 and 3·0 s. g. The Carnmoney mineral being of low specific gravity, a solution of about 2·0 was sufficient. The rock being crushed up and sifted, to get rid of small dust, which would have rendered the result less palpable, was thrown into a dish filled with the solution. Everything but the new mineral sank to the bottom. The latter was then skimmed off, and immediately washed with distilled water to which a little potassic iodide had been added, to dissolve any red iodide which would otherwise be thrown down, and finally washed with distilled water. When a sufficient quantity of the mineral had been thus collected it was again treated in the same way, and thus was cleared of a few particles of augite, &c., which had been caught up in the first floatation.

In this way about 3 grammes of the mineral were obtained, perfectly free from admixture, and quite sufficient to yield exact analytical results.

The analysis was conducted in the usual way, by the fusion of the powdered mineral with the alkaline carbonates. Although it appears to be nearly altogether decomposed by boiling (when powdered) in strong hydrochloric acid, the fusion process seems to be the most complete method, and is the shortest in the end; because, if boiling with acid is depended on, the insoluble residue will be found almost invariably to contain undecomposed silicates, giving an excess in the amount of silica.

The ferrous iron was determined according to Early's method, namely, by decomposing the mineral with hydrofluoric acid, and estimating the ferrous iron as quickly as possible by means of a standard solution of bichromate of potassium.

As it was not easy to obtain enough of the mineral to enable its specific gravity to be taken in the ordinary way, its gravity was determined in a somewhat novel way. It floats on, and is hardly affected, even after some months, by strong sulphuric acid of the usual density, viz., 1·84. Dilute sulphuric acid, of the density of the mineral, was prepared, and the specific gravity determined by means of a delicate hydrometer;[1] the density by this means was found to be only 1·76, so

[1] Sonstadt's solution might have been used, but sulphuric acid was found to be more convenient at the time.

The analysis was performed by me in the Laboratory of the Royal College of Science in Dublin, by permission of Prof. Galloway.

that the mineral is the lightest silicate known of, almost. This is very remarkable in a mineral containing such a very large percentage of iron, the peroxide amounting to 20·720 per cent.

Physical characters.—Colour, velvet black. Hardness, about 2, brittle; lustre, waxy but dull; streak, olive brown; Blow-pipe with difficulty fusible at edges to a black glass, which in some specimens is magnetic. Very slightly affected by strong HCl or H_2SO_4 when in the mass, but decomposed by the former when boiled in it in powder. Occurs filling amygdaloidal cavities in the basalt of Carnmoney Hill, near Belfast; Shane's Castle, Lough Neagh[1]; &c.

Chemical Composition and Formula.

I shall compare my analysis of this mineral with analysis of delessite and chlorophæite.

	Hullite.	Delessite.[2]	Chlorophæite.[3]
Silica . . . (SiO_2), .	39·437	31·07	33·30
Alumina . . (Al_2O_3), .	10·350	15·47	—
Peroxide of iron . (Fe_2O_3), .	20·720	17·54	—
Protoxide of iron . (FeO), .	3·699	4·07	26·70
Protoxide of manganese (MnO), .	Trace.	—	—
Lime . . . (CaO), .	4·484	19·11	—
Magnesia . . (MgO), .	7·474	0·46	—
Water . . . (H_2O), .	13·618	11·55	40·00
Carbonic acid . (CO_2), .	Trace.	—	—
	99·782	100·00	100·00
Formula	$[CaMgFe'']_3[Al'''Fe''']_4Si_6O_{21} + 7H_2O$	—	$Fe\,Si\,O_3 + 6H_2O$
Sp. gr., ...	1·76	2·89	2·02

Like other ferrugenous chlorites (as delessite), to which group this mineral appears in many respects to be allied, it is extremely difficult to express its composition by a chemical formula. In the first place, there is always some degree of alteration, which has changed the characters of the mineral; and besides, it is difficult to say whether these minerals are true silicates or combinations of silicates with aluminates. With regard to the last, it would be very difficult to decide

[1] A specimen of basalt from this locality containing very large cavities filled with this mineral is to be seen in the Museum of the College of Science, Dublin, as in the specimen mentioned, p. 161; the mineral is called obsidian.

[2] Dana's *System of Mineralogy*, 1874, p. 497.

[3] *Ib.*, p. 410. Also *Western Isles of Scotland*, &c. John Macculloch, M.D., p. 505.

one way or the other in the present case, and I would prefer to content myself with calculating a formula on the supposition that that mineral is only a silicate. However, the above analysis does not give a reasonable formula in its entirety. Calculated as it stands, it gives

$$M''_3\, M'''_4\, Si_6O_{21} + 7H_2O,$$

which fails to agree with any type of silicate I know of.

If, however, we subtract one molecule of peroxide, and suppose it to exist as a hydrate, and not combined, we get

$$(M'_3\, M''_2{}'\, Si_6O_{18}) + H_6\, M'''_2o_6 + 4H_2O,$$

the first member of which is a condensed meta-silicate on the type

$$H_{12}\, Si_6O_{18}$$

which would bring it sufficiently near the type of talcose and chloritic minerals. However, the general constitution, even allowing for this, is entirely different. Then again, we may suppose the excess of peroxide, as in the above, to act the part of an acid, an aluminate, or a ferrate, which is not improbable, and we thus get a formula not unlike that which has been proposed for ripidolite, but the silicate belonging to a different condensed meta-silicic series, viz.,

$$[M''_3\, M'''_2O_6 + M'''_2H_6\, Si_6O_{18} + 4H_2O],$$

a part of the water in this case being basic, as I have but little doubt it is, acting in fact as a protoxide.

It is extremely probable that the last formula gives a fair representation of the molecular composition of this new mineral.

I should wish to draw attention to one or two remarkable points about this mineral. 1° the very large percentage of iron it contains, and the small quantity of magnesia, although it is extremely refractory before the blow-pipe; and 2° its very low specific gravity, notwithstanding the quantity of iron it contains. The last circumstance is, I think, due to the very large percentage of water.

With regard to its claims to be an original mineral, and not simply a product of alteration, I would like to point out one or two strong evidences. The mineral occurs coating or filling ordinary amygdaloidal cavities in the basalt. It is clearly a product of infiltration into these cavities, and not an alteration of a previous mineral, because the walls of the cavities are quite distinct from the mineral. Were it a product of alteration, it might be expected to merge into the rock itself, or such minerals as might be altered to such a composition, such as olivine or augite; but this is not the case, the olivine and the augite are quite distinct from it. Under the microscope the mineral may be observed to fill up the cavities previously left in the rock; and crystals of

augite, felspar, and olivine may be seen to penetrate it in such a way as to leave no doubt that the Carnmoney mineral has been deposited in those spaces.[1]

Under these circumstances I consider it to be an original (but secondary) mineral, and believe it to be a new variety of the chloritic group, and a well-marked one. I therefore propose to give this Irish variety a distinguishing name.

Macculloch, in his description of the mineral chlorophæite, apologises for giving it a new name, saying that though it may afterwards turn out a variety only, its characteristics are strongly marked; and that the best chance of its obtaining future investigation will be derived by giving it a conspicuous place in the list of minerals. On the same grounds I venture to name the present mineral as a new species. Since distinctness of colour and hardness may vary in different specimens, and therefore mislead—and there is no earthly use in commemorating a single locality when the mineral may hereafter be found in hundreds of places—I submit that the best name would be that of an individual. I propose to name this species or variety Hullite, after Professor Hull; first because it has been analysed and described during his directorate of the Geological Survey of Ireland; and last, but not least, in commemoration of the valuable work he has done in the elucidation of the microscopic mineralogy of the rocks of Ireland, more especially that of the basalts.

In order to set at rest any question as to the mineral being an alteration product, Professor Hull, at my request, had some slices of the rock made, and the microscopic examination of them fully bears out my previous remarks, viz., that the mineral is perfectly distinct from, and does not merge into any part of, the basalt.

Part II.—On the Microscopical Structure of the Olivine Basalt of Carnmoney Hill, Co. Antrim. By Professor E. Hull, M. A., F. R. S.

The rock occurs as a dark crystalline mass, with columnar structure, filling the neck of an old volcanic vent of the Miocene age. (*See* Geology of the Country around Antrim, *Mem. Geol. Survey*, Sheet 21, p. 30). With the lens it is seen to consist of black glistering crystals of augite, set in a paste consisting of a light-coloured waxy felspar (plagioclase), and large and small grains of an opaque, black, dense mineral, with smooth, somewhat conchoidal, fracture, and brown streak. This unknown mineral is that to which Mr. Hardman has applied the name "Hullite," and the chemical composition of which he has determined. The olivine, though seen to be remarkably abundant

[1] See Prof. Hull's remarks further on.

under the microscope, is scarcely to be identified without the aid of a high magnifying power.

Microscopical appearance.—Under the microscope, and with a low power (25 diameters), the slice is seen to consist of light brown augite, without crystalline form, in which are imbedded short prisms of plagioclase, imperfect crystals of olivine, and a very few grains of magnetite. But the most abundant mineral is that now for the first time described by Mr. Hardman. It is of a dark umber brown colour, almost opaque, except at the edges, and it forms not only individual masses, but permeates the whole rock, filling the interstices, and enclosing the other minerals. In one instance, where it has apparently filled in a cell in the rock, the central portion is vacant; but it often forms considerable masses. As it does not polarize, it cannot be considered as in a crystalline molecular condition; and in its distribution, and relation to the other minerals, it assumes very much the character of amorphous chlorite. Like chlorite, also, it has every appearance of being a secondary mineral, formed after the consolidation of the rock, and with a high power shows a stalagmitic or chalcedonic structure, with wavy bands.

One of the most interesting circumstances regarding this rock is the abundance of olivine in its unaltered condition. In no other instance, amongst the basalts and dolerites of Antrim which I have examined, have I found it so abundant, and in its original state olivine, as is well known, is a mineral very liable to decomposition, and generally it has been completely removed, the outer form only being preserved. In the case, however, of the basalt of Carnmoney Hill, it is as abundant and as fresh as in the lavas of Vesuvius. This can be determined by the aid of the polariscope, by means of which the crystalline grains of olivine are separated out from the augite with which it might otherwise be confounded; but under polarized light, not only may the outline of the crystalline forms be recognised, but the mineral affords (on rotating the analyzer) the well-known alternation of colours, from ruby red to sap green, characteristic of this mineral. On the other hand, the colours of the augite are blue, grey, light pink, and yellow. The crystalline forms of the olivine are only imperfectly developed. The crystals of plagioclase—probably labradorite felspar—are well and sharply defined, and seem to have crystallized out before those of augite and olivine. With the polariscope they show the usual parallel-banded structure, varying with the angle of the analyzer.

From the remarkably fresh appearance of the olivine one might infer that this rock was comparatively recent, did we not know, from physical considerations, that it must be older than the Glacial and Pliocene periods.

XXVIII.—Further Observations on Pyrrol and its Derivatives.

By Chichester A. Bell, M.B., University Dublin.

[Read, June 24, 1878].

Synthesis of Pyrrol.

Several attempts which I have made to effect the synthesis of pyrrol have not been successful. The following experiment is chiefly of interest as suggesting a process by which bases of similar constitution are likely to be obtained artificially. When vapours of diethylamine $(C_2H_5)_2$ HN, are passed through a heated tube packed with recently-ignited pumice, they experience but little change if the temperature be much below that of redness. On the other hand, a good red heat is sufficient to decompose the base into a variety of products, amongst which ethylene, free hydrogen, cyanogen, and hydrocyanic acid, are easily recognised. If the tube be of sufficient length, the current of vapour not too rapid, and the temperature that of *incipient* redness, a liquid is obtained containing, besides much diethylamine, a considerable quantity of pyrrol. The change probably consists in a direct separation of hydrogen, thus—

$$\left.\begin{array}{l} CH_3-CH_2 \\ CH_3-CH_2 \end{array}\right\rangle NH = \left.\begin{array}{l} HC=\overset{H}{C} \\ \;| \\ HC=\underset{H}{C} \end{array}\right\rangle NH + 3H_2$$

I have not in this way prepared any large quantity of the base, but in all cases have estimated the product by the rapidity and intensity with which the vapours issuing from the tube exhibited the fir-wood reaction, the amount of precipitate yielded by the acidified distillate with mercuric chloride, stannous chloride, etc., and by the quantity of pyrrol-red obtained by boiling the liquid in the receiver with strong hydrochloric acid.

I think it not unlikely that the conversion of diethylamine into pyrrol may be effected in a more simple way.

On the so-called ethyl-pyrrol of Lubawin.

In my previous communication on this subject (these Proceedings, 2nd Series, vol. III., Science, page 33), I described a series of bases derived from pyrrol by the substitution of various alcoholic radicles for one atom of hydrogen. One of these, namely ethyl-pyrrol, C_4H_4 $N(C_2H_5)$, differed widely in its properties from the similar base pre-

viously described by Lubawin.[1] According to this chemist, when iodide of ethyl acts upon potassium-pyrrol C_4H_4NK, substitution of the group C_2H_5 for potassium takes place, a body of the composition $C_6H_9N = C_4H_4N(C_2H_5)$ being formed. This base was said to have a turpentine-like odour, to boil between 155° and 175°C., and to turn brown rapidly on exposure to air. The metal potassium acts with great vigour upon pyrrol, expelling hydrogen and producing potassium-pyrrol; but upon ethyl-pyrrol from mucate of ethylamine it has little or no action. It would be contrary to analogy to suppose that in Lubawin's base the ethyl-group does not occupy the position of the potassium in potassium-pyrrol, and it was hence difficult to resist the conclusion that the bases prepared from potassium-pyrrol and from ethylammonium mucate must be identical. On repeating Lubawin's experiment I have found this to be the case. Potassium-pyrrol is most easily prepared in a state of purity by adding to pyrrol, contained in a flask with inverted condenser through which a stream of dry hydrogen is passed, rather less than the calculated quantity of bright metallic potassium. The action is violent at first, and must be moderated by the application of cold; towards the close it must be assisted by a gentle heat. The contents of the flask are finally heated to fusion, allowed to cool, the flask broken, and the solid mass dropped into a mortar containing anhydrous ether. It is then quickly powdered, the ether (which removes unaltered pyrrol) quickly poured off, and the powder again transferred to a flask provided with an inverted condenser. It is then covered with rather more than the theoretical quantity of ethyl iodide, and the mixture boiled for a couple of hours, a chloride of calcium tube being placed in connexion with the upper end of the condenser so as to prevent ingress of moisture. Towards the close of the boiling, a not inconsiderable amount of ammonia is evolved, evidently due to secondary decompositions. On fractionally distilling the contents of the flask, a very large quantity of *ethyl-pyrrol* is obtained, boiling at 131°C., and having all the other properties of the base from ethylammonium mucate. Above 131°C. a quantity of secondary products of inconstant boiling-point comes over, the thermometer rising to 180°. It is this mixture that Lubawin evidently mistook for ethyl-pyrrol, no doubt regarding the principal product of the reaction as unaltered pyrrol, from which indeed it differs but little in odour or boiling-point. (Pyrrol boils at 133°C.)

It is thus clear that only one ethyl derivative of pyrrol is yet known, no doubt having the constitution—

$$\begin{array}{l} \quad\ \ \mathrm{H} \\ \mathrm{HC}=\mathrm{C}\diagdown \\ \ \ | \qquad\quad \mathrm{NC_2H_5}. \\ \mathrm{HC}=\mathrm{C}\diagup \\ \quad\ \ \mathrm{H} \end{array}$$

[1] "Zeitschrift für Chemie," [2] v. 399.

Condensation-products of Ethyl-pyrrol.

In my former paper I mentioned that ethyl-pyrrol may be boiled for some time with strong hydrochloric acid without experiencing any change, in this respect differing from pyrrol. If the boiling is continued for a sufficiently long time, this is not the case. Even when dilute acid is used, the base gradually dissolves, forming a deep-red solution which is not rendered turbid by the addition of water. This solution contains the hydrochlorate of a new base, or perhaps salts of several new bases. The product is obtained by precipitating the acid solution with ammonia in excess. On drying the precipitate *in vacuo*, or at a gentle heat, it is obtained as an amorphous powder, which is nearly insoluble in water, but is readily taken up by alcohol or ether. Its colour varies from pale brown to black, accordingly as it has been prepared with dilute or with strong acid. Heated on the water bath it constantly loses weight, giving off a peculiar odour. Analyses showed it to be of uncertain composition, the following being the mean results:—

$$C = 68{\cdot}64, \qquad H = 8{\cdot}81, \qquad N = 9{\cdot}63.$$

This composition agrees most closely with the formula $C_{16}H_{24}N_2O_2$, which requires—

$$C = 69{\cdot}56, \qquad H = 8{\cdot}69, \qquad N = 10{\cdot}1.$$

Such a body might be formed according to the following equation:—

$$3C_6H_9N + 2H_2O = C_{16}H_{24}N_2O_2 + \underset{\text{Ethylamine.}}{C_2H_7N},$$

and, in fact, when potash has been used as a precipitant, it is easy to detect abundance of ethylamine in the filtrate. The powder melts at 165°–170°C., but not sharply. It is soluble in all acids (except nitric acid) even when dilute. On evaporating the solution in hydrochloric acid on the water-bath, the hydrochlorate remains in the form of blood-red scales, showing no trace of crystalline form. These re-dissolve easily in water. The base is precipitated from its acid solutions by minute quantities of nitric acid or nitrates, as a flocculent brown powder. Bromine or chlorine water, stannic and mercuric salts, likewise precipitate it. In its characters and composition it approaches some of the amorphous alkaloids extracted from cinchona bark.

Pyrrol-red (which, however, is entirely destitute of basic properties) is produced from pyrrol in a perfectly similar way,

$$3C_4H_5N + H_2O = C_{12}H_{14}N_2O + NH_3.$$

Carboxyl derivatives of Pyrrol.

In my former paper I mentioned that when the primary amine salts of mucic acid are distilled, there are produced, besides substituted pyrrols, a series of bodies having the composition of amides of mono-

and di-carboxyl derivatives of these pyrrols. The corresponding acids had not at that time been procured. These amides are rather stable compounds, and are very slowly attacked by mineral acids and alkalis.

If it is attempted to decompose them by prolonged boiling with strong alkaline solutions, it is impossible to prevent the decomposition of the acids as fast as formed. I have found, however, that they may be easily split up by enclosing them in sealed tubes with strong alcoholic potash, and exposing the tubes for some time to a temperature of about 120°C. They are then resolved with facility into free ammonia-base and the potash salts of the corresponding acids; thus—

$$\underset{\text{Dimethyl-carbopyrrolamide.}}{C_4H_3N(CH_3)(CONHCH_3)} + KHO = \underset{\text{Methyl-carbopyrrolic acid.}}{C_4H_3N(CH_3)COOK} + NH_2CH_3.$$

$$\underset{\text{Diethyl-carbopyrrolamide.}}{C_4H_3N(C_2H_5)CONHC_2H_5} + KHO = \underset{\text{Ethyl-carbopyrrolic acid.}}{C_4H_3N(C_2H_5)COOK} + NH_2C_2H_5.$$

I have not, however, been able to obtain amyl-carbopyrrolic acid. Its amide when heated with potash yields amyl pyrrol, amylamine, and potassic carbonate.

$$C_4H_3N(C_5H_{11})CONHC_5H_{11} + 2KHO = C_4H_4N(C_5H_{11}) + K_2CO_3 + NH_2C_5H_{11}.$$

The potassium salts of these acids are obtained in the solid form by evaporating their alcoholic solutions. They are very soluble in water and alcohol. By cautiously adding to their concentrated aqueous solutions dilute hydrochloric acid in *very slight* excess, the mixture being carefully cooled from time to time, the acids are separated as flocculent precipitates which soon become crystalline. The crystals must be rapidly washed with cold water. To remove small quantities of silica (derived from the glass tubes) they must be dissolved in ammonia and again precipitated with hydrochloric acid. When thoroughly free from mineral acid they may be crystallized from water at about 90°C. (not higher), in which they are freely soluble.

Methylcarbopyrrolic acid crystallizes in needles which are very soluble in alcohol and ether. It melts at 135°C.; heated a little beyond this point, it breaks up into methyl-pyrrol and carbonic anhydride.

$$C_4H_3N(CH_3)COOH = C_4H_4N(CH_3) + CO_2.$$

It volatilizes with partial decomposition in a current of steam. Its salts are as a rule easily soluble in water: those of the alkalis and alkaline earths dissolve in alcohol. *Argentic methyl-carbopyrrolate* $C_4H_3N(CH_3)COOAg$, obtained by double decomposition, crystallizes from much boiling water in transparent prisms which deflagrate feebly when heated. ·446 grams of the finely powdered salt, mixed with sand to avoid loss by too rapid decomposition, gave on cautious ignition ·206 grams of silver = 46·19 per cent.; calculated = 46·55 per cent.

Ethylcarbopyrrolic acid, similarly prepared, bears a great resemblance to the methylated acid. It is, however, rather less stable, more soluble in water, and melts at 78°C. The silver salt is much more

soluble in boiling water than that of the previous acid. Found, 43·89 per cent. of silver; calculated, 43·9 per cent.

In contact with boiling water, or in the cold in presence of even highly dilute mineral acids, these two acids are rapidly resolved into methyl- or ethyl-pyrrol and carbonic anhydride. Their solutions in water below its boiling point are tolerably stable so long as they are contained in smooth glass vessels; but rough surfaces (filter paper) or fine points cause rapid decomposition. They give with neutral ferric chloride a red colour.

Ethyl-dicarbopyrrolic acid.—$C_4H_2N\ (C_2H_5)\ (COOH)_2$ is obtained by the action of large excess of alcoholic potash at 130° C, upon *triethyl-dicarbopyrrolamide*, one of the decomposition products of ethylammonium mucate. The potassium salt crystallizes from alcohol in long needles. The acid is obtained from its aqueous solution by precipitation with hydrochloric acid. It appears as a sandy powder, quite insoluble in boiling water, and not decomposed by it. It is easily soluble in alcohol and ether. By crystallization from dilute alcohol it is procured in brilliant needles, which when heated do not melt, but at about 250° C. are resolved into ethyl-pyrrol and carbonic anhydride.

$$C_4H_2N(C_2H_5)\ (COOH)_2 = C_4H_4N(C_2H_5) + 2CO_2$$

Analysis gave the following results :—

Found.		Calculated.
C = 52·26	. . . . . .	52·26
H = 5·27	. . . . . .	4·91
N = 7·96	. . . . . .	7·65

The nitrogen determination was a little too high, owing to the accidental employment of slightly impure soda-lime.

The salts of this acid are mostly soluble in water. The silver salt is an insoluble sandy powder. Found, 53·97 per cent. Ag: calculated for, $C_4H_2N(C_2H_5)\ (COO\ Ag)_2$ = 54·4 per cent.

The acid is very slowly decomposed in the cold by concentrated hydrochloric acid. Boiling dilute nitric acid dissolves it, but deposits it unchanged on cooling. Strong and warm nitric acid also dissolves it, but does not again deposit it on dilution.

About two per cent. of its weight of this acid may be obtained from the mucate of ethylia.

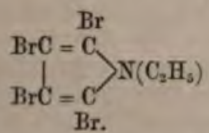
Action of Bromine upon Pyrrol Derivatives.

When bromine is added to a solution of ethyl-pyrrol in ether or chloroform, the mixture becomes dark-coloured and gives off hydrobromic acid. The reaction takes place with greater smoothness when alcohol is used as a solvent; but the best result is attained when ethyl-pyrrol is shaken with excess of bromine water, added gradually.

The insoluble solid compound formed is filtered off and repeatedly crystallized from boiling spirits of wine, in which it is sparingly soluble in the cold. It then crystallizes in brilliant colourless needles which melt at 90° C., or beneath warm spirit. They are easily decomposed above 100° C. It might have been expected that a body so poor in hydrogen as ethyl-pyrrol would have given an addition compound with bromine. But analysis shows that towards this reagent the pyrrol nucleus behaves like benzol.

Found.	Calculated for. $C_4Br_4NC_2H_5$
C = 17·3	17·51
H = 1·43	1·21
Br = 77·2	77·85
N = —	—

The compound remains apparently unchanged when digested with excess of bromine water. No doubt it has the following constitution:—



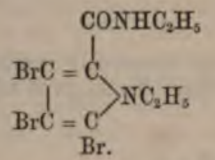
Diethylcarbopyrrolamide, $C_9H_{14}N_2O$, also does not unite directly with bromine. When bromine dissolved in chloroform is added to a chloroform solution of the amide, it is at once decolourized: but even in the cold, fumes of hydrobromic acid are given off, and, on allowing the chloroform to evaporate, a tenacious mass is left, in all probability a mixture of unchanged amide with a substitution compound.

When shaken with bromine water, diethylcarbopyrrolamide yields an insoluble substitution compound and a soluble oxidation product. To obtain the first, careful manipulation is required, since it passes into the second with the greatest ease. The amide is first dissolved by continued agitation in so much warm water that nothing separates on cooling. Bromine water is then dropped in very cautiously, the mixture being shaken after each addition. The two new compounds are produced simultaneously, the first separating in small clots, and rendering the mixture milky. On continuing the addition of bromine, a point is reached at which the milkiness suddenly disappears, and the liquid becomes transparent, while the clots adhere to the sides of the flask. This clearing marks the point at which all the amide has been acted upon, and any further quantity of bromine added is used up in oxidizing the clots. The liquid is filtered, and the solid residue is repeatedly crystallized from 60% alcohol, in which it is freely soluble on heating. It separates on cooling, when pure, as a jelly-like mass of long silky needles of extreme tenuity, which require prolonged heating to 100° C. to dry them. The substance is insoluble in water,

but dissolves with facility in alcohol or glacial acetic acid. It melts with partial decomposition at 120° – 121° C. Analysis gave the following numbers:—

Found.	Calculated for. $C_9H_{11}Br_3N_2O$
C = 26·65	26·79
H = 2·95	2·73
Br = 59·36	59·55
N = —	—

It is evidently derived from the amide by the substitution of three atoms of bromine for three atoms of hydrogen. Its constitution is most probably



When the clear liquid from which this body has been filtered off is evaporated on the water-bath, much hydrobromic acid escapes, and a crystalline body is deposited. This must be removed before the liquid has gone quite to dryness, and it is then easily purified by crystallization from water or alcohol. The new body forms small hard transparent crystals which melt with decomposition at 197° C. It dissolves easily in all alkalis, and is reprecipitated by dilute acids. Its ammoniacal solution, when evaporated to dryness on the water-bath, leaves a residue which is not dissolved by water, and which appears to be the original body, still, however, containing a little ammonia. This is not the behaviour of a true acid. Boiling with fixed alkalis decomposes it completely, ethylamine, alkaline bromide, and other bodies not as yet investigated, being formed. Analysis leads to the formula $C_9H_{11}Br_2N_2O_3$.

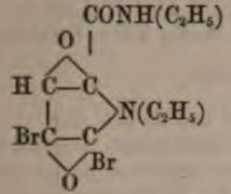
Found.	Calculated.
C = 30·08	30·42
H = 3·31	3·09
Br = 44·87	45·07
N = 7·8	7·88
O = —	—

This compound is also obtained when the tribrominated diethylcarbopyrrolamide is treated with bromine water. The reaction is perhaps the following:—

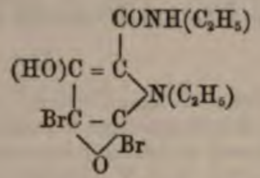
$$C_9H_{11}Br_3N_2O + Br_2 + 2H_2O = C_9H_{11}Br_2N_2O_3 + 4HBr.$$

It is not, however, easy to frame a constitutional formula for it which shall be in harmony with such a change, unless we suppose

that it contains one atom of hydrogen more than is indicated by analysis, and give to it some such structure as the following :—



or



either of which would require 3·37 per cent. of hydrogen.[1] This view is quite justified by the analysis of the corresponding methyl-compound given below. The second formula would have the advantage of accounting for the property of the compound of dissolving in alkaline solutions. As I have pointed out, the ammonia compound is decomposed by simple heating on the water-bath, which would seem to point to the presence of a hydroxyl group. It is unlikely that any oxidizing action has been exerted upon either of the lateral groups, C_2H_5; for, firstly, the compound readily evolves ethylamine when heated with caustic potash, and secondly, tetrabrominated ethyl-pyrrol is scarcely attacked even when heated with bromine water.

From *dimethylcarbopyrrolamide* similar bodies may be obtained by shaking with bromine water. I have not isolated the first of these, having had only a small quantity of amide to work with: but the second or oxidized compound is obtained as easily as its ethyl-analogue, which it resembles in crystalline form, solubility, &c. It melts, however, at a higher temperature, 204° – 205° C., at the same time decomposing. I give a partial analysis of it.

Found.	Calculated for. $C_7H_8Br_2N_2O_3$
C = 25·27	25·6
H = 2·61	2·44
Br = 48·23	48·78

The study of the action of potash and of reducing agents upon these bodies will probably explain their constitution.

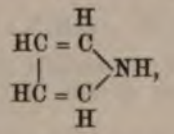
[*Note added in the Press.*]

[1] A more carefully prepared specimen of the body gave, on analysis, C = 30·42 and H = 3·64; agreeing well with the formula $C_9H_{12}Br_2N_2O_3$, which requires C = 30·34, H = 3·37 per cent.

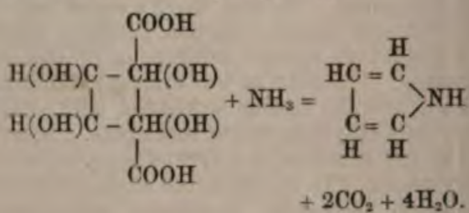
With regard to the cause of the difference in the behaviour of the two acids, but little can be said. According to all experiments hitherto published, it is extremely probable, if not absolutely certain, that the relative position of the carbon atoms is the same in both. Both are *normal* compounds; and the differences between them must be due to the positions of their hydroxyl groups. If we give to either acid (*e. g.* mucic acid) the formula

$$CO_2H - CH(OH) - CH(OH) - CH(OH) - CH(OH) - CO_2H,$$

and to pyrrol the constitution proposed by Baeyer,



the formation of the latter is easily explained—



At the same time one or both of the carboxyl groups may become amidated, and may remain with the pyrrol nucleus. In saccharic acid now we may imagine a greater number of hydroxyl groups to be joined to the carbon atoms in the neighbourhood of the carboxyl, and consequently the latter to be rendered unstable. Hence, when ammonium saccharate is distilled, it parts with both carboxyl groups, and gives pyrrol, but no carbopyrrolic acid. This explanation is reasonable, for we know that oxyacids as a rule lose CO_2 much more easily than the acids from which they are derived, and those in which the OH is near the carboxyl more easily than those in which it is remote from it. Thus, succinic acid, when heated, yields an anhydride, whilst tartaric acid (dioxysuccinic acid) decomposes into carbonic anhydride and pyroracemic acid. Again, salicylic acid separates more easily into phenol and CO_2 than either of its isomerides, para- and meta-oxybenzoic acids; whilst benzoic acid may be distilled unchanged. Many similar examples might be adduced.

We purpose studying the action of ammonia on other highly oxygenated acids.

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XX.—COMPUTATION OF TIDES AT FLEETWOOD.—DISCUSSION OF CORRESPONDING PHENOMENA IN DIFFERENT YEARS, ETC. By JAMES PEARSON, M. A., Ex-Scholar (15th Wrangler), Trinity College, Cambridge.

[Read, November 11, 1878.]

my first[1] communication on the subject of the Tides, I gave a brief count of the guiding principles which led me to the construction of vised Tables for their computation, and the graphic process by which obtained a clue to them. My second[2] Paper showed the results of eory as compared with observation, and proved that the course of e "diurnal inequality" was correctly explained and traced out. e object of my present Paper is to illustrate the correspondence of les in different years, having the same constituents approximately. a velocity of angular rotation, equal and opposite to that of the rth, be supposed to be communicated to the moon, the earth will be luced to rest, and the moon's path in the sky will be represented by ort of spherical helix, the convolutions of which will ascend from t to west, whilst the moon's declination passes from south to north; d during that interval the path of the "anti-moon" will be also presented by a corresponding spherical helix, but differing from the mer in this respect, that its convolutions will descend from east to st, whilst the actual moon's declination has the fore-mentioned nges. To use a familiar illustration—in the one case we shall have eft-handed cork-screw motion, and in the other a right-handed one. nsequently, the lunar and anti-lunar tides are essentially different their operation, and so are the solar and anti-solar tides. On the thod which I have adopted in dealing with the subject, any single e during any year will only have one tide corresponding to it, out ll the tides in any other year, and hence it becomes interesting to uire how far such co-ordinate tides (as I may term them) agree h observation as years advance; and with this purpose in view, ill select a series of such tides, commencing with the year 1873, l occurring in the same month (April) in each year subsequent; o another series occurring in the same month (September) in each r. The results will speak for themselves; but I would invite ention to the tides for 1872, Sept. 15, evening, and 1873, Sept. 5, ning. These have almost identical constituents; and yet, from nospheric causes, we have in one case a resulting tide three inches ve calculation, and in the other a resulting tide eleven inches ow.

[1] *Vide ante*, page 72. [2] *Vide ante*, page 111.

Computation of Tides.

Anti-lunar and Solar.	1874, April 26, Morning.		1875, April 15, Morning.		1876, April 4, Morning.		1877, April 23, Morning.		1878, April 13, Morning.	
	h. m.	ft. in.	h. m.	ft. in.	h. m.	ft. in.	h. m.	ft. in.	h. m.	ft. in.
Moon's Transit,	7 25′	21 2	7 7	20 9	7 16	20 11	7 12	21 0	7 18	21 0
Inc. for Anti-lunar,		− 1		− 1		− 1		− 1		− 1
Moon's Hor. Parallax,	55′ 0″ −	− 5	57′ 17″ −	+ 5	58′ 55″ −	+ 14	59′ 21″ +	+ 14	59′ 0″ +	+ 12
Moon's Declination,	19° 55′ S. asc.	0	24° 2′ S. asc.	− 6	25° 2′ S. asc.	− 8	12° 28′ S. asc.	+ 3	19° 43′ S. asc.	+ 0
Sun's Declination,	13° N.	+ 2	9° N.	+ 1	5° N.	+ 1	12° N.	+ 1	8° N.	+ 1
	ft. in. 20 9 obs.	20 10	ft. in. 20 8 obs.	20 8	ft. in. 21 7 obs.	21 5	ft. in. 22 2 obs.	22 5	ft. in. 22 2 obs.	22 0

Lunar and Anti-solar.	1872, Sept. 15, Evening.		1873, Sept. 5, Evening.		1874, Sept. 24, Evening.		1875, Sept. 13, Evening.		1877, Sept. 20, Evening.	
	h. m.	ft. in.	h. m.	ft. in.	h. m.	ft. in.	h. m.	ft. in.	h. m.	ft. in.
Moon's Transit,	21 37	24 5	21 48	24 8	21 56	24 9	21 34	24 5	21 48	24 8
Inc. for Lunar,		+ 5		+ 5		+ 5		+ 5		+ 5
Moon's Hor. Parallax,	60′ 25″ +	+ 20	60′ 27″ +	+ 20	59′ 36″ +	+ 15	56′ 27″ +	+ 0	54′ 2″ +	− 12
[illegible]	21° 22′ S. asc.	− 2	23° 24′ S. asc.	− 4	17° 23′ S. asc.	+ 3	22° 1′ S. asc.	− 3	15° 22′ S. asc.	+ 4
	[illegible]	+ 5	7° S.	+ 4	0° S.	+ 5	5° S.	+ 5	2° S.	+ 4
	[illegible]	[illegible]	ft. in. [illegible]	26 9	ft. in. 27 1 obs.	27 1	ft. in. 24 8 obs.	25 0	ft. in. 24 7 obs.	24 9

It may be of interest to place on record examples of the most extreme cases of high and low tides which I have as yet observed. The tides in these instances were produced, of course, under circumstances least favourable and most favourable to their development.

	1876, March 19, Evening, Anti-lunar and Anti-solar.		1874, March 19, Evening, Lunar and Solar.	
	h. m.	ft. in.	h. m.	ft. in.
Moon's Transit, ...	18 8	20 0	11 55	26 3
Inc. for Lunar or Anti-lunar,		− 4		+ 7
Moon's Horizontal Parallax,	54′ 14″ −	− 12	61′ 22″ +	+ 27
Moon's Declination, . . .	28° 44′ N. asc. des.	− 19	5° 27′ S. asc.	+ 14
Sun's Declination, . . .	1° S. N.	− 3	0°	+ 7
	ft. in. 15 8 obs.	16 10	ft. in. 30 11 obs.	30 10
	(Helbrè Island.)			

In the former case the tide fell fourteen inches below its expected height; but the barometer on this occasion stood at 30°·7′, and the wind was very cold and heavy from the North. Such a low tide had not been remembered for at least twenty years.

Annexed are comparisons for the month of September, 1878.

Date.	Calculation.	Increm. or Decrem.	Observation.	Increm. or Decrem.	REMARKS. Barom., Wind, &c.
1878.	ft. in.	in.	ft. in.	in.	
Sept. 12,	25 10	+ 18	25 9	+ 9	30·2 W.N.W., half gale.
	27 4	− 15	26 6	− 9	30·3 W.N.W., signal flying.
" 13,	—	—	—	—	
	26 1	+ 14	25 9	+ 18	30·4 W.N.W., calm.
" 14,	27 3	− 18	27 3	− 18	30·1 W.S.W., calm.
	25 9	+ 9	25 9	+ 9	30·0 W.S.W., calm.
" 15,	26 6	− 18	26 6	+ 5	29·9 S.W., freshening.
	25 0	+ 6	26 11	+ 11	29·4 S.W., equinoctial.
" 16,	25 6	− 19	27 10	− 18	29·5 N.W., gale.
	23 11	+ 4	25 6	− 6	29·8 N.N.W., abating.
" 17,	24 3	− 18	25 0	− 7	29·9 W.S.W., backing.
	22 9	0	24 5	− 3	29·8 W.S.W., backing.
" 18,	22 9	− 17	24 2	− 15	29·7 N.W., strong.
	21 4	+ 1	22 11	− 1	29·7 W., strong.
" 19,	21 5	− 14	22 10	− 17	29·8 W., half gale.
	20 3	− 6	21 5	− 23	29·9 W., unsettled.
" 20,	19 9	− 11	19 6	− 10	30·1 W., gusty.
	18 10	− 3	18 8	− 3	30·4 W., calm.

	Calculation.		Increm. or Decrem.	Observation.		Increm. or Decrem.	Remarks. Barom., Wind, &c.
		in.	in.	ft.	in.	in.	
		7	+ 7	18	5	+ 8	30·4 W., calm.
		2	+ 7	19	1	+ 16	30·3 signal out.
		9	+ 16	20	5	+ 7	30·0 S.S.W., fresh.
		1	+ 11	21	0	+ 16	29·8 S., calm, heavy rain.
		0	+ 15	22	4	+ 13	29·6 S.W. to N.W., signal out.
		3	+ 12	23	5	+ 4	29·7 N.W., calm.
		3	+ 20	23	9	+ 22	30·0 N.W., gusty.
		11	+ 17	25	7	+ [illegible]	30·0 W., gusty.
		4	+ 17	27	5	+ 5	29·6 S.W., falling fast.
	[illegible]	7	+ 6	27	10	+ 5	29·7 N.N.W., fresh, cold.
	28	3	+ 20	28	3	+ 20	30·0 N.W., calm.
	29	8	− 5	29	11	− 8	30·0 W.S.W., calm.
27,	29	3	+ 11	29	3	+ 10	30·0 W., calm.
	30	2	− 6	30	1	− 5	30·1 W., calm.
28,	—		—	—		—	
	29	8	+ 1	29	7	+ 4	30·0 W., calm.
29,	29	9	− 12	29	11	− 13	30·0 W., calm.
	28	9	—	28	10	—	30·0 W., calm.

XXXI.—COMPUTATION OF OCCULTATIONS AND ECLIPSES. By JAMES PEARSON, M. A., F. R. A. S., late Scholar of Trinity College, Cambridge, Vicar of Fleetwood.

[Read, February 10, 1879.]

THE methods of calculating the circumstances connected with the above phenomena, as given by Mr. Woolhouse in the appendix to the *Nautical Almanac* for 1836, or as contained in Admiral Shadwell's work on the subject, are confessedly so laborious and puzzling, that any arrangement by means of which the same results might be obtained with more facility must be esteemed desirable. The graphic process delineated by Mr. Penrose in his valuable treatise is a step in this direction, but it is capable of being so modified as that it can be easily performed in about twenty minutes, and bring out the times of occurrence within thirty seconds. To explain the mode by which this is accomplished is the object of the present communication.

For ordinary use in these operations it is necessary first to construct a series of concentric ellipses, having a common semi-axis major ten inches in length. The semi-axes minor are in the same straight line, but are of lengths 10 sin 2°, 10 sin 4°, 10 sin 6°, &c., up to 28°, which is the extreme range of the moon's declination. Ordinates are drawn to the semi-axis major, the abscissæ of which are successively 10 sin 15°, 10 sin 30°, 10 sin 45°, &c., corresponding to the hours I, II, III, &c. The construction of this diagram will not be a matter of much difficulty to those who are acquainted with the elements of Conic Sections, and it must be treasured up for subsequent use, being the only diagram required in the process.

The next step is to construct a scale of equal parts, the length of ten divisions of which is represented by the number $\frac{10000}{P\rho \cos l}$, where P is the moon's reduced relative Horizontal Parallax, ρ the factor which deduces the Earth's radius at the proposed place from the equatorial radius, and l the *geocentric* latitude. Since this scale involves both the latitude and the parallax, it is called the latitude-parallax-scale, and the number referred to is to be taken from an ordinary inch-diagonal navigation scale. This done, the moon's reduced horary motion in right ascension, and given horary motion in declination, will enable us to lay down the moon's relative orbit by its aid, which orbit must be subdivided into hours and minutes by the compasses, commencing at the instant of the moon's true conjunction. The position of the centre of the projection of the parallel of latitude of the given place must be found by the number representing,

$$\{\text{diff. dec.} - P\rho \sin l \cos \delta\},$$

the notation being the same as before; and it will be below or above the moon's centre at conjunction according as the above quantity is + or −; and this being ascertained, the ellipse-diagram will guide in tracing out as much of the ellipse as is traversed during the progress

of the eclipse, and in subdividing it into intervals of hours and minutes. Lastly, from the latitude-parallax-scale is taken an extent equal to the sum of the semi-diameters reduced of the sun and moon, and one foot being set on the moon's path and the other on the path of the observer, the compasses are moved backwards and forwards till the points fall into the same hour and minute in both paths, thus showing the required times.

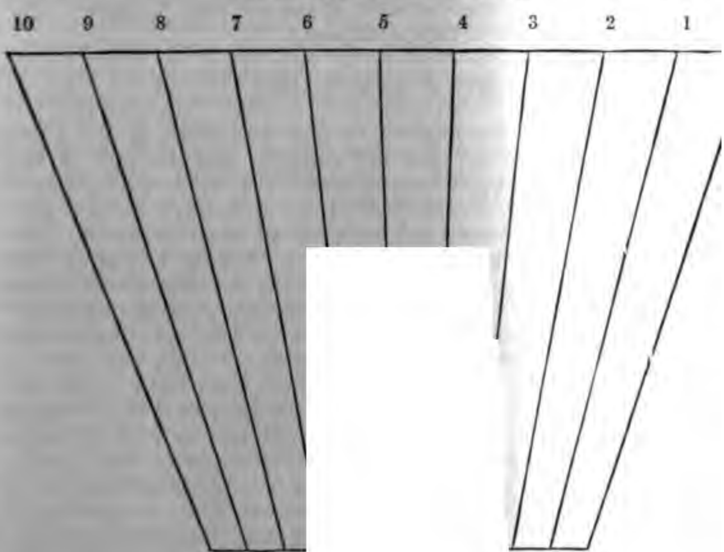
To facilitate the subdivision of the latitude-parallax-scale, and of the hours on the moon's path, two diagrams may be drawn as on page 185, only enlarged in magnitude :—

The moon's horary motion in right ascension is taken from the "variations for 10^m," given in the *Nautical Almanac*, by calling the seconds of *time* minutes of *arc*, and increasing these quantities half as much again. The moon's horary motion in declination is taken from the corresponding quantities in the same page, by regarding the *seconds* of arc as *minutes* of arc, and dividing by 10.

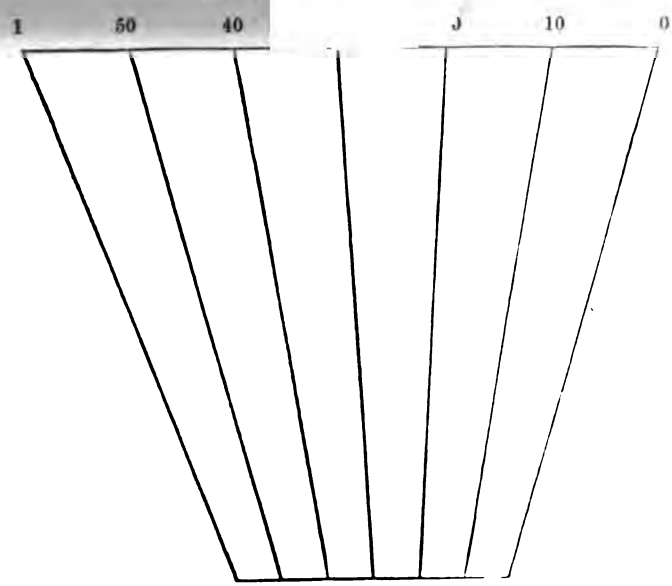
TABLE *of Values of Ten Divisions of the Latitude-Parallax-Scale, and of* Pp sin l, *for Greenwich Lat. Geoc.* 57° 17′ N., *used in construction of Occultations and Eclipses.*

Horizontal Parallax.	Value of Ten Divis.	Difference.	Pp sin l ×	Difference.	Horizontal Parallax.	Value of Ten Divis.	Difference.	Pp sin l ×	Difference.
53′ 0	302·4	1·2	41′·28	·15	58′·0	276·3	1·0	45′·17	·16
·2	301·2	1·1	·43	·16	·2	275·3	·9	·33	·15
·4	300·1	1·1	·59	·16	·4	274·4	1·0	·48	·16
·6	299·0	1·1	·75	·16	·6	273·4	·9	·64	·15
·8	297·9	1·2	·91	·15	·8	272·5	·9	·79	·16
54′·0	296·7	1·1	42′·06	·15	59′·0	271·6	1·0	·95	·15
·2	295·6	1·0	·21	·16	·2	270·6	·8	46′·10	·16
·4	294·6	1·1	·37	·15	·4	269·8	·9	·26	·15
·6	293·5	1·1	·52	·16	·6	268·9	·9	·41	·16
·8	292·4	1·1	·68	·15	·8	268·0	·9	·57	·16
55′·0	291·3	1·0	·83	·16	60′·0	267·1	·9	·73	·15
·2	290·3	1·1	·99	·16	·2	266·2	·9	·88	·16
·4	289·2	1·0	43′·15	·15	·4	265·3	·9	47′·04	·15
·6	288·2	1·0	·30	·16	·6	264·4	·8	·19	·16
·8	287·2	1·1	·46	·15	·8	263·6	·9	·35	·16
56′·0	286·1	1·0	·61	·16	61′·0	262·7	·9	·51	·15
·2	285·1	1·0	·77	·15	·2	261·8	·8	·66	·16
·4	284·1	1·0	·92	·16	·4	261·0	·9	·82	·15
·6	283·1	1·0	44′·08	·16	·6	260·1	·8	.97	·16
·8	282·1	1·0	·24	·15	·8	259·3	·8	48′·13	
57′·0	281·1	1·0	·39	·16					
·2	280·1	·9	·55	·15				× cos δ.	
·4	279·2	1·0	·70	·16					
·6	278·2	1·0	·86	·15					
·8	277·2	·9	45′·01						
58′·0	276·3	·10	·17						
			× cos δ.						

FOR LATITUDE-PARALLAX-SCALE.



FOR M[illegible]



XXXII.—On the Supernumerary Rings of the Rainbow. By Philip Burton.

[Read November 11, 1878.]

The explanation of the rainbow, which was given by Sir Isaac Newton in his "Optics," did not comprise any account of the coloured rings frequently to be seen within the violet of the primary bow, and, more rarely, outside that of the secondary; nor is it probable that these phenomena had been noticed when he wrote. The theory thus remained defective until 1803, when Dr. Young showed that the supernumerary colours were caused by the interference of two portions of light, which, though incident upon the drops of rain at different angles, were emitted parallel, and reached the eye, after having traversed unequal spaces. According to this principle, the places of the additional rings, with respect to the primitive rainbows, must vary with the size of the drops by which they are formed; but a different method of estimating the effects of interference, devised by Sir G. Airy in 1838, seems to be generally adopted at the present day. In the account of the latter system, which is given in a recent publication,[1] it is stated universally that the calculation shows "there is a succession of feebler and feebler concentric circles of maximum brightness—inside the principal maximum in the primary bow, and outside it in the secondary"; and no reference being made to the effect of different dimensions of the drops, the results obtained would seem to be independent of such variation, from which it may be inferred that the phenomena are always similar, and that all the drops are equally effective to produce them. As many appearances of these bows have come under my notice, I can perceive that the conclusions now referred to are not warranted by observation; I am, therefore, induced to put forward this Paper, in which I shall endeavour to show that the positions and breadth of the interference bows do actually vary within certain limits, though not perhaps to the extent which Dr. Young's theory would seem to require; also, that the phenomena in question can only be produced by drops, which do not exceed a certain size.

The most usual appearance presented by the additional bows agrees very well with the description given in 1722 by Dr. Langwith, who seems to have been one of the first to observe them. "The colours of the primary bow," he says, "were as usual, only the purple very much inclining to red, and well defined: under this was an arch of green, then alternately two arches of reddish purple, and two of green, and under all a faint appearance of another arch of purple. . . . We had here four orders of colours, and perhaps the beginning of a fifth; and the breadth of the first series so far exceeded that

[1] Chambers' "Encyclopædia."

of any of the rest, that, as near as I could judge, it was equal to them all taken together." (*Philosophical Transactions*, vol. xxxii., p. 243.) On several occasions I have seen bows corresponding with this description; but the breadth of the colours was not always the same, being sometimes very narrow, and at other times more considerable. It does not often happen that so many coloured rings become visible together, though in almost every rainbow I find that the first additional ring of green can be observed in contact with the primitive violet: the appearance of a reddish or purple ring within the green is also not unusual; and on less frequent occasions these colours are repeated in the same order. In almost every instance we can see that the interference rings decrease in brightness as they recede from the primitive bow, and they are also narrower than the rings which compose the latter.

On the 26th of June, 1877, at 7·40 p.m., I observed a rainbow with supernumerary rings differing in some particulars from those now mentioned. In this instance there was in contact with the violet a ring of red, which was followed by other rings in this order—green, red, green, red, green, red. These colours were almost as bright as those of the principal bow; and although the last ring of red seemed as brilliant as any of the others, there was no indication of any fainter rings beyond it. They were not formed at all parts of the arc, but only in positions where the sun seemed to shine strongly; also, the breadth of each ring seemed to be equal to the sun's diameter; and the colours observed were red and green—not purple and green, as they usually appear.

The additional colours on the outside of the secondary bow are very rarely seen on account of their faintness; indeed, I have not been able to notice in this position more than a single green ring, and that only on a few occasions.

An important principle in connexion with the supernumerary colours is, that there is a limit to the size of the drops in which they are formed; so that, although the smaller drops may produce them, those of larger size are quite inefficient to do so. This principle may be expected, from Dr. Young's theory; for it appears, from his mode of calculation, that the number of returns of the rays within a given distance from the caustic increases with the size of the drops: consequently, the rings being more numerous in equal spaces, the breadth of each must diminish as the drops grow larger; and when a certain limit is attained, the opposite colours being very close, will reach the eye compound or white, just as if no interference took place. That this is really the case may be shown by examining the coloured rings produced by single drops of rain in the following manner:—

If we take a fine hair, or a slender fibre of flax, &c., and, holding both ends of it in the fingers, immerse it in water, again withdrawing it in such a manner as will cause some particles of the fluid to adhere to it; upon bringing one of these particles very close to the eye, and in

a proper position, whilst at the same time the sun shines upon it, we shall observe a brilliant arc of rainbow lying apparently within the drop, and accompanied by many supernumerary rings. The colours of these rings are alternately green and purple, and they are all concentric with the principal bow. If we now alter the position of the drop a little towards the sun, these colours will disappear, and the secondary bow, encircled with brilliant supernumerary rings on its outside, will come into view. By changing the position of the drop with respect to the eye, at the same time retaining it at the proper elongation from the sun, we get a view successively of every portion of the arcs produced by the drop, and can perceive that the form of each bow is nearly that of a circle, convex to the sun. The curvature of the caustic for the secondary bow is much greater than that of the primary, so that within the limits of the visible arcs it is seen to intersect the primary at two points equally distant from the centre of the drop, its supernumerary rings converging towards it as they approach those points.

In order to show that the large drops do not produce the interference rings, we may contrive to make a hair take up a comparatively large drop of water, or we may bring some of the small drops together so as to form larger ones. Now, upon examining those whose diameters are greater than about $\frac{1}{25}$ of an inch, we can perceive that they form beautiful bows, both primary and secondary, but in each case without any trace of supernumerary rings. In these drops, also, it is seen that there is "a continued diffusion of fainter light within the bright termination which forms the rainbow," and the colours of the latter are more brilliant and homogeneous than those formed in the small drops, especially the red, which is strikingly distinct at the edge. The limit of size beyond which interference does not take place may be determined by subjecting one of the large drops to a gentle evaporation. For this purpose the heat of the sun, in summer, will be sufficient. As soon as the diameter of the drop is decreased below the assigned quantity the supernumerary rings will be formed, being at first very narrow, though in great numbers, and they will continue to be produced at all smaller sizes. Upon examining various dimensions of the drop, we observe that the nearer its diameter approaches the limit referred to the more numerous are the rings, but the smaller sizes cause the colours to be broader. Also, as the size of the drop decreases, the colours produced are somewhat blended, the red of the principal bows appearing partly orange or yellowish even at the edge, and the supernumerary colours becoming yellowish and dark purple. When the drop is still further diminished, the primitive bows are exactly similar to the others, consisting of two colours only, and, before it finally vanishes, only bright and dark bands are produced.

The foregoing experiments may be made with other fluids, and it appears that the limiting diameter of the drop diminishes as the refractive power increases: thus it is less in oil of turpentine, linseed oil, &c., than in water. The rings are particularly brilliant and numerous in

oil. The principle might also be illustrated by melting small pieces of glass into globules of various sizes, and all the phenomena referred to can be seen in the dewdrops hanging from slender blades of grass, &c.

The diameter of the largest raindrop which can produce the supernumerary colours (estimating it without micrometrical appliances) is about $\frac{1}{25}$ of an inch; but from the general appearance of the bows it is probable that the drops which form them are much smaller. Dr. Young has calculated the size of those necessary to cause the phenomena described by Dr. Langwith to be about $\frac{1}{76}$ of an inch, and says it would be sufficient if they were between $\frac{1}{70}$ and $\frac{1}{80}$ (*Phil. Trans.*, vol. xciv., p. 48). It is certain that a slight difference in size does not interfere with the regularity of the bows; for, if we look into the web of a very minute spider, which, resembling gossamer, is to be met with on the ground, we can often perceive upon it drops of dew not exceeding $\frac{1}{100}$ of an inch in diameter, and these collectively form several supernumerary rings, which appear perfectly regular and concentric with the outside bow, although it can scarcely happen that the drops should be exactly equal in size.

If the colours of the iris be seen through a telescope, as in M. Babinet's experiment, in which they are observed in a descending column of water let down through a small aperture, it is evident that the limit at which interference ceases to take place ought to be greater than when the phenomena are observed by the naked eye. Professor Potter, in detailing the results of his observations, mentions[2] that, when the water was $\frac{1}{10}$ of an inch in diameter, the interference bars were plainly visible, but in some other instances they did not appear at all. He has not stated the cause of their non-appearance, but it was probably owing to the thickness of the column of water exceeding the limit at which interference occurs.

Dr. Pemberton, in endeavouring to explain why the supernumerary colours usually appear more vivid under the upper part of the bow, remarks that "it is most likely they are formed in the vapour of the cloud which the air, being put in motion by the fall of the rain, may carry down along with the large drops,"[3] but it being certain that the clouds produce no such colours, we should rather attribute the circumstance to the greater abundance of the small drops in the higher regions, their number being diminished as they descend, on account of several particles coalescing with one another, and forming drops too large to produce colours by interference. It is also very probable that the unusual vividness of these bows, which occasionally occurs, is owing to the preponderance of small drops in the shower which produces them, and to their general uniformity in size. It may seem inconsistent with this explanation, that the additional colours often

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[2] *Philosophical Magazine*, May, 1855, p. 321.
[3] *Philosophical Transactions*, abridged, vol. vi., p. 140.

appear very vivid in heavy rains consisting of large drops, but this circumstance is easily accounted for. In some of the heaviest showers which I have seen, when the rain was carefully observed falling between the eye and an aperture in a wall, &c., behind which a dark screen was placed, there could be plainly noticed, amongst the large drops, a great number of small ones, which, being impeded by the air, did not descend with the velocity of the others. These small drops may also be occasionally observed in the open air, when the heavy drops, descending in oblique lines, are crossed nearly horizontally by a multitude of spherules wafted by the wind in various directions. It is then these minute particles, which, being present in every shower, produce, when more or less uniform in dimensions, the colours of the supernumerary bows.

It would appear, from Dr. Young's theory, that in the iris formed by very small drops there ought to be a dark space between the primitive and supernumerary rings; but however small may be the particles which we examine, these colours lie close to one another, unless, indeed, the primitive bows be supposed to have vanished, and that all the rings are "spurious," being produced by rays of unequal lengths. This theory, also, does not explain the fact which appears to be well established, that the ordinary rainbow actually occurs within the calculated place of the caustic; neither does it explain the mixing of the colours at the outer edge of the bow produced by the small drops, which circumstance, taken in connexion with the diminished intensity of the light, would seem to indicate that, in this case, the rays of equal lengths have, at least, partially disappeared, although manifestly this does not take place in the large drops.

NOTE ADDED IN THE PRESS.

The phenomena here described are those which are seen in globular drops; but as small particles of water adhering to a hair are generally distorted into a spheroidal form, the bows produced by them are somewhat different in figure. Also, if the hair does not pass through the centre of the drop, one of the bows is sometimes absent, or is divided into branches. The large drops are not sensibly distorted; and on this account, when I first perceived that they did not form additional rings, I considered that the production of the latter might be a consequence of the spheroidal figure of the small drops: repeated experiments, however, convinced me that such could not be the case, and that the different appearances observed in both cases were entirely dependent on the size of the particles.

XXXIII.—SEA-BEACHES, ESPECIALLY THOSE OF WEXFORD AND WICKLOW. BY G. H. KINAHAN. (With Plates 4, 5, 6, 7.)

[Read January 27, 1879.]

THE travelling of sea-beaches is a very interesting subject to the geologist, but it is one most important to the engineer, as it affects so strongly the questions of the proper positions and construction of harbours, piers, and groynes. During the time I have been engaged on the Geological Survey of Ireland (over twenty years) I have had, when stationed in maritime districts, favourable opportunities of observing the sea-beaches. This has been specially so during the last six years, while I have been engaged in examining the counties of Wicklow and Wexford, and in those years the observations made were both numerous and minute.

From the Papers read before the different Scientific Societies it would appear that two of the principal points of controversy as regards this subject are:—Whether are the wind waves or the tidal currents the principal moving agents in the shifting of the beaches? and—Can large stones be carried by somewhat ordinary ocean currents in deep water? To these subjects I have also paid special attention.

I propose laying before the Academy the results of my observations, which relate to:—

I. The travelling of beaches due to the tidal currents.
II. The effects of the wind waves.
III. Carriage of stones in deep water.
IV. The effects of the travelling of beaches on the harbours and piers between Hook Point (Admiralty Chart, Ireland, sheet xiv.) and Dalkey Island (Admiralty Chart, sheet xvi.); concluding with
V. A discussion of the groynes on the coast-line between Hook Point and Dalkey Island.

I. *Travelling of Beaches due to the Tidal Currents.*

This Paper will more especially refer to the observations made on the coast-line of south-east Ireland included in the Admiralty Charts, Ireland, sheets xiv., xv., and xvi.[1] On the accompanying map (Plate 4) the principal on-shore flow-tide currents have been indicated; those going with the course of the tide, the counter-currents (counter-tides), and the half-counter-tides.

As pointed out in Haughton's *Manual of Tides and Tidal Cur-*

[1] Sheet xv. is on the scale of two inches to the mile. The chart on the scale of one inch cannot now be procured; while the other charts, on the larger scale, have not as yet been published.

rents, the wave of the "flow-tide" coming in from the Atlantic strikes the west coast of Ireland, and divides, part going northward round the north coast, and part eastward, along the south coast, until it has passed Carnsore Point, where it enters the Irish Sea and flows northward until it meets the north wave, in the vicinity of the Isle of Man. These waves form, in places, on-shore currents; and the most conspicuous of those on the coast-line which we are now considering are as follows:—When the south wave passes Hook Point it sends a branch to the N.E., along the east shore of the Hook promontory to Bannow Bay, where, at the Keragh Islands, it is met by a "counter-tide." West and east of the Saltee Islands there are also two branch on-shore currents. The western Saltee current runs north-eastward to Kilmore Pier, where it turns westward and forms the "counter-tide" that meets the Hook current at the Keragh Islands. At the meeting of these two currents a shoal has accumulated. Under ordinary circumstances the current from Hook carries the beach with it only to the neighbourhood of Keragh, as proved by the fact that the stones from the Hook promontory are rarely found beyond Keragh. The "counter-tide" west of Kilmore carries the beach N.W. along Ballyteige Bay; and during the last forty years[2] (since the Ordnance Maps were made), has lengthened the Ballyteige sandhills more than two hundred feet.

The eastern Saltee on-shore current flows first N.E. and then eastward along the coast to Carnsore Point, during two-thirds of the "flow-tide"; but during the last two hours of the "flow"[3] there is a "half counter-tide" setting westward from Carnsore to the Kilturk Bank. The driftage towards the N.E., due to both the western and eastern Saltee currents, forms, at their colliding, long ridges called St. Patrick's Bridges, between the two Saltees and between the north Saltee and the mainland; while the meeting of the driftage due to the east current and to the "half counter-tide" from Carnsore have formed the Kilturk Bank.

In the Irish Sea the on-shore current runs north from Carnsore to Greenore,[4] where three currents, at least, are produced; one going north along the east margin of the Long Bank, the second in the channel to the west of the Long Bank, while the third sweeps round the shore of the South or Ballygeary Bay. The first or east current carries fragments of the Greenore and Carnsore rocks and other detritus to the Long Bank, and from it north-eastward to the Blackwater Bank, and from the latter to the "Shingle Beach," Cahore,

[2] Here and elsewhere forty years is mentioned, as it was about that time the Ordnance Survey Maps were published. Prior to them there are no authentic records of the coast-line.

[3] This is an average, as the "half counter-tide" begins sooner during "springs" than in "neaps."

[4] The Greenore mentioned in this Paper is in the County of Wexford, and must not be confounded with the Greenore to the north (County of Louth).

and thence still further northward along the Wexford and Wicklow beaches; those fragments having been traced to Greystones, a little south of Bray Head. The second or middle current also carries fragments of the Greenore and Carnsore rocks northward in seven fathoms water, as has been proved by Thos. Winder, M. Inst. C.E., the Resident Engineer of the Ballygeary Pier, while making a submarine survey in connexion with the works; and the third or on-shore current carries similar fragments along the beach westward and afterwards northward.

The detritus carried by the second and third currents goes to the Dogger Bank[5] off the mouth of Wexford Harbour. From this bank some of the smaller stones are carried along the south or Hantoon channel into the harbour, and lodged on the western side of the Rosslare Bank; while the rest of these are swept N.E. across the deep water to the Blackwater Bank. Few or none of them seem to be carried across the North Channel into the North Bay; for, during my numerous visits to that bay, scarcely a fragment of the Greenore or Carnsore rocks was found along its beach; and when found they were only to the northward, in the vicinity of the south end of the Cahore "Shingle Beach." This accumulation of shingle is described further on.

The water of the lagoon causes various complications off the mouth of Wexford Harbour, as the tide within the lagoon flows and ebbs after the changes of the tide outside. In the early period of the outside "flow-tide," the northward current along the Raven and the Blackwater cliffs seems due to the efflux from the lagoon, but afterwards to a "flow-tide" current. There are alterations in the currents due to the changes of the Dogger Bank, but these changes are in part due to the wind waves.

The Cahore Shingle Beach is about three miles long, and is largely composed of fragments of the Greenore and Carnsore rocks; with these there are others from the cliffs along the Blackwater coast. From Cahore Point, during the latter part of the "flow-tide," a "half counter-tide" runs towards the S. W., which keeps back the "Shingle Beach," and prevents it from approaching within half a mile of the Point.

Opposite Courtown (north of Cahore) is the "nodal" or "hinge line" of the tides in the south portion of the Irish sea, where the rise is least and the current greatest. The on-shore current sweeps the coast line from Cahore to Kilmichael Point; but off the latter it is met by a "counter-tide," the meeting and colliding of the two forming the "Kilmichael Race," which extends from the Point to off the north end of the Glassgorman Bank. The refuse from the shipping at Courtown Harbour, such as bits of brick, tile, slate, coal, &c., are principally stranded along the beach a few miles S.W. of Kilmichael

[5] This Dogger Bank must not be confounded with the bank in the German Ocean.

Point. On this beach Greenore and Carnsore rock fragments are not uncommon; but in the two small bays to the north of the Point, the gravel and shingle is made up almost solely of the local rocks, many of the fragments being more or less angular. In connexion with these two bays are interesting phenomena to be mentioned hereafter in connexion with the wind waves.

From Arklow to Wicklow Head the general driftage of the beaches is northward; but in connexion with most of the headlands there are "half counter-tides" for a few hours before high water, especially during springs.[6] The debris from the shipping at Arklow is principally beached on the strand S.W. of Mizen Head; off Wicklow Head there are short "counter-tides" forming two or more races, the principal one being Bride's Race.

North of Wicklow Head a current from the S.E. strikes the coast line at Six-mile-Point, and there divides, part going northward, but a considerable portion southward, to form the counter-tide that carries the beach with it towards Wicklow. To its meeting with a current from the south is due the just-mentioned Bride's Race. In connexion with Wicklow Head there is, before high water, a "half counter-tide" running east to Wicklow town, which prevents the "full" beach extending south-eastward to the head. The current going north from Six-mile-Point is deflected by the land drainage from The Breaches; and at the colliding of these, the "Breaches Shoal" has accumulated. North of The Breaches a current runs northward to opposite Delgany, where it is met by a "counter-tide," and in the dead water produced at their junction the Mouldditch Bank has been formed.

Farther north a current from the south-eastward impinges on the coast near Greystones, a part going south to form the just-mentioned "counter-tide," and the rest northward to Bray Head, off which it is met by a "counter-tide," and at their meeting a race is formed.

To the north of Bray Head a current from the S.E. strikes the coast line at the tower No. 4, near the middle of Killiney Bay: here it divides, a part constituting the "counter-tide" that runs S., carrying the beach with it to Bray, and from thence running to Bray Head to form the previously-mentioned race. Here, as at Wicklow, there is a little before high water, a current running E. from the Head to the S. end of the strand, which prevents the "full" beach extending to the high ground of the hill. Another similarity between these two beaches is, that from tower No. 4 to Bray, and from Six-mile Point to Wicklow, the pebbles forming the beaches gradually

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[6] These currents seem to occur at every rocky headland immediately before high water, especially during springs. They are of such short duration that usually they pass unobserved—yet they are important, as to them is due that the beach is kept back from reaching to the Heads.

increase in size, and at the south end of both strands the beaches are principally shingle.[7] From tower No. 4 the beach in Killiney Bay travels northward with the current; but in the vicinity of Dalkey Island there is, a little before high water, a "half counter-tide" south-westward.

The "ebb-tide" waves flowing out of the lagoons and estuaries deepen the channels and cut away the beaches margining the narrows; but elsewhere on this coast line they do not affect the beaches, except in the vicinity of Courtown, where the average rise of tide is about three feet. Even here the travelling of the beach, which is solely due to the ebb-tide current, is very small, as it only continues for an hour or so during spring-tides.

II. *The Effects of the Wind Waves.*

The waves of this class that act on this coast are of two kinds, viz., "ground swells," or waves generated by storms in the Atlantic or the Channel, and the waves directly due to the winds blowing on the coast. Their effects are either to pile up and fill the beaches, or to cut them out.

The ordinary wind waves assist the "flow-tide" current if both waves are going in the same direction, or if the wind waves strike the beach at an acute angle; if they strike the beach at a right angle they fill it up, forming "fulls" and "storm beaches," while if they are running in a more or less opposite direction to the flow-tide they cut out the beach. As an example: Let the flow-tide current be from south to north on an east coast. If the wind is blowing from any point between S. and E., E.S.E. by E. the wind waves assist the tidal current; but if it is blowing any point between E.S.E by E. and E.N.E by E. strong, the wind waves will stop the travelling of the beach, and pile it up, forming "full" or "storm beaches;" while if the wind is coming from any point between E.N.E. by E. and N. a "cutting out tide" is the result. This cutting out is due to the "dancing waves," generated by the meeting of the tidal current and the wind waves, which toss and churn up the sand and other detritus, thus causing it to be carried out by the back-wash into deep water. A continuous heavy wind in the same direction as the flow-tide will accelerate the carriage of a beach to such a degree that every particle of sand, gravel, and shingle may be carried with the tide, thus leaving the up-stream portion of a beach empty. These seem to be the general effects; but near Courtown, where the difference between low and high-water is

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[7] In a Paper "On the Drifting power of tidal currents *versus* that of wind waves" (Proc. Royal Irish Academy, 2nd ser., vol. ii. p. 448), I have demonstrated that the reason why the larger pebbles occur down stream on some beaches is because the "back-wash" carries down and out to sea the small gravel and sand, leaving behind it on the slope of the beach the larger stones, which are pushed higher and carried farther along the beach by each successive wave.

only a few feet, and when the "ebb-tide" current is excessive, during heavy storm waves, the cutting out seems to continue for a little time into the ebb.

"Ground swells" act differently to the ordinary wind waves, as they break in on the coast line, perpendicularly or nearly so, with an undulating or rolling motion which generates a considerable "suck" or back-wash. The wind waves, which on one portion of a coast line assist the tidal current when this latter is flowing in a normal direction, may, on another portion, where there is a "counter-tide," act differently. This is exemplified in the embayment between Hook Promontory and the Saltee Islands. Here a gale from the S.W. assists the tidal current between the Hook and the Keragh Islands, and rapidly carries the beach to the N.E.; but the same gale striking the beach in "the bite" on the north of Crossfarnoge Point, to the east of Ballyteige Bay, where it is perpendicular to the tide current, forms a great "full", while along the Burrows to the north of this bay it meets the counter-tide obliquely, and cuts out the beach. Such winds also stop the seaward driftage of the shoal at Keragh Islands, thus causing great "fulls" in the strands at this part of the coast line, During such winds, at certain seasons, great masses of sea-wreck or drift seaweed are piled up in "the bite" to the north of Crossfarnoge. These weeds grow principally on the rocky bottoms adjoining the Saltee Islands, and during May and November, the seasons for the shedding of their leaves, the storms set the leaves afloat, and the tidal current carries them northward into Ballyteige Bay, where they are met and stopped by the storm waves and driven on shore at "the bite," to be stranded when the tide ebbs. Under ordinary circumstances the slope of the beach at "the bite" is less than 10°, and sometimes only 5°, but after a twenty-four hours' S.W. gale the slope often rises to over 35°. Three or four high tides, however, will reduce it nearly to its normal condition; the "full" being carried N.W. along the strand of the Burrows rapidly filling up what had been cut out by the gale.

Between the Saltees and Carnsore, S.E., and S. winds accelerate the travelling of the sands to the Kilturk Bank; but here they are met by the "half counter-tide," thus causing "fulls" in this locality. In this place, at the proper seasons, there is also a great stranding of sea-wreck. These weeds grow near the Saltees to the southward, and near Carnsore to the eastward, and are carried to this locality by the tidal current from the S. W., and by the "half counter-tide" from the E. Ordinarily the weed is beached on the coast at the small headland near Kilturk; but if, while it is floating, there is a gale from the S. E., a considerable quantity of it will be landed on the shore N.E. of Carnsore.

Observations in connexion with the "half counter-tide" running westward from Carnsore are instructive. In a gale from the S. W., during the first four hours of the "flow-tide," the beach travels rapidly towards Carnsore; but after the "half counter-tide" sets in,

the driftage is westward. This forms a "full" (*a*, Fig. 1, Pl. 5) on the slope of the beach, and gives the beach a lower (*b*) and an upper (*c*) slope, with a cess, as the Dutch engineers call it (*a c*), between; thus producing a section, of a form best calculated to break the force of the waves in the succeeding two hours of the full tide, which prevents the storm waves from having full effect on the coast line. Ordinarily, however, this beach is much cut out, especially by "ground swells;" and when the shores are empty, gales, whether from the S. W., S., or S. E., have great effect. Consequently, during the last forty years, the coast line between Lady's Island Lake and Kilmore has been considerably denuded away, especially in the vicinity of St. Patrick's Bridge. These beaches, during the continuous E. and N. E. winds of the spring of 1876, changed from their ordinary gravel into "fulls" of shingle. This must have been solely due to the "flow-tide" currents, as for months no wind waves broke on the coast.

On the east coast, between Greenore and Dalkey Island, as a general rule the beaches are travelling north, and this is accelerated by the south and south-east winds; there are, however, long stretches of beach swept by "counter-tides," at which places these winds generate "cutting-out tides." Although the most continuous winds are those from the S. W. and W. S. W., yet they are not effective winds, as they come across the land; their only effects being those due to the "ground swells" generated by them and the driftage seaward of the Æolian sands, so prevalent on the east coast line of Ireland. The winds that do the most damage on this coast are those from the S.W.; but the most continuous that effect the beaches are those from points between E. and N., and their results are perhaps the most interesting.

The points of interest in the South or Ballygeary Bay, N. W. of Greenore, will have to be mentioned hereafter when describing the harbours and groynes, so at present they may be passed over. In the North Bay all winds seem to "cut out," this being due to the complication of the tidal currents, the beaches rarely being full, except in the summer and autumn, when there are no winds. On account of the great cutting out along this beach, the marginal cliffs have been vastly denuded within the last forty years. The "Cahore Shingle Beach," at the north of the bay, is fullest during S. and S. E. gales; while it is cut out by winds from the N. E. and by "ground swells." After S. and S. W. gales it is often smothered up with fine sand, blown from the adjoining accumulations of Æolian drift.

A little N. W. of Cahore Point is Poulduff Pier, with the beaches accumulated since it was erected, while farther northward are the piers and other works at Courtown. These will be described hereafter; but it may now be mentioned that between Cahore and Kilmichael Points the driftage is nearly altogether northward, and accelerated by the S. and S. E. wind, while the N. to E. winds cut out the strands.

On the coast line S. (Fig. 4, Pl. 6) and N. (Fig. 5, Pl. 6) of Kilmichael Point there has been considerable denudation of the sandhills since the Ordnance Survey was made (forty years). In the first locality

have been carried away by gales from the S.E. Here there ly swift tidal current to the N.N.E., which, under ordi- ances, carries all the beach with it, and leaves no pro- en the sea and thesandhills; consequently, under these during S.E. gales the wind waves have full power on the they then rapidly denude away. As previously mentioned, l Point, to the N. E., is a "race," due to the meeting of the just-mentioned tidal current and a "counter-tide" the northward; but the latter is affected by continuous the north and north-eastward, prolonging it southward, he "counter-tide" round the Point into the bay to the Consequently, under such circumstances these winds, ng out, form "fulls" for about a mile in the strands to michael Point, thus preserving the sandhills. The cross as accompanying Fig. 4a, Pl. 6, show this beach to true scale. represents the beach in June, 1875, when it was one continuous , up which the storm waves from the S. E. could rush with full ; while cross section No. 2 shows exactly the same line after con- ous gales from the north-eastward, which had accumulated a wide shore that perfectly protected the sandhills from the S. E. gales.[8]

Northward of Kilmichael Point, in the bay at the mearing of the counties Wicklow and Wexford, the denudation of the sandhills has also been considerable within the last forty years (Fig. 4, Pl. 6), more than 20 acres in the townlands of Cloon, Lower and Upper, having been swept away. Here there is a "counter-tide" running S., and the wind from points between E. and N. accelerate the southward travel- ling of the beach, but E. winds cut it out. During none of my visits were the beaches "full," there being a gradual slope, up which the storm waves from the S. E. could run with full force, and impinge on the sandhills. According to the information supplied to me, the latter are only denuded by S. E. gales, these being most effective when the strand is empty.[9]

Farther northward are the beaches of the bays at Wicklow and Bray; it is here unnecessary to describe them further than to mention the "storm beaches." These peculiar ridges are very rare S. of Wicklow Head; in fact, on that portion of the coast they are so

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[8] This is a most remarkable place, as, in recent years, the sandhills at one time seem to be forming, and at others wasting away. Some of the old men can point out the extensions of the sandhills prior to the Ordnance Survey, and the roads that used to lead to them, which now end at steep cliffs; while one old man, in June, 1875, pointed out, in a cliff that had only been uncovered the previous winter, an old quarry that must have been worked with *iron* tools prior to the accumulation of the sandhills that existed when the Ordnance Survey was made.

[9] Although I visited this place frequently, I never had the satisfaction of finding the beach "full"; while the information I received was unsatisfactory, as the native said, "everything travels to the north." Yet I could prove by the carriage of the rock fragments, also by the experiments made at my different visits, that the beach travelled south during "flow tide" ("counter-tide").

indistinct, that no one unacquainted with such accumulations would observe them; but they are characteristic of the S. portion of the strands of Wicklow and Killiney Bays, always occurring in connexion with the "counter-tides." They are best developed during directly on-shore gales from the E. If formed during the rise of the spring tides, each ridge after being produced is destroyed by the next "flow-tide," but if formed during the fall of the springs, successive nearly parallel ridges accumulate (Fig. 2, Plate 5), which remain till the next spring, when they are levelled, and the material carried southward.[10]

It ought to be specially pointed out, that *the storms which cut out the beaches may not be the same as those which denude away the marginal cliffs*. The beaches are principally "cut out" by "ground swells," or storm waves, that come in an opposite, or obliquely opposite, direction to the "flow-tide" current, or they may be carried forward by the sole agency of the tidal current, or by the latter assisted by wind waves coming in a similar direction. Any of these causes may scoop out or sweep a strand bare, and leave it with little or no beach; and, under the latter circumstances, the storm waves act with full force on the marginal cliffs.[11] A small storm when the strand is empty may do great damage on the coast line; while a great storm with a full beach will do scarcely any. The best section of a beach seems to be that similar to Fig. 1, Plate 5, having below, or to seaward, a slope (b), above which is a flat or "cess" (a, c), and higher up a second slope (c), which is succeeded by a second "cess." Such beaches, however, seem to be of rare occurrence, they usually having cross sections similar to that in Fig. 4*a*, Pl. 6, with a slope below and a wide "cess" above; but on the "cess" in this case the waves lose a great deal of their power before they reach the marginal cliffs.

Extraordinary high tides, unaccompanied with wind, seem to do little or no damage on an open seaboard. In March, 1867, there was a remarkably high tide on the coast of Galway, the traces of which were scarcely perceptible along the open coast, even on the sandhills; but in the land-locked bays it did considerable damage to the piers

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[10] On this portion of the Irish shore, where there is a tidal current, the "storm beaches" only exist during the intervals between the spring tides; but in other places, where there is a "rise" and "fall" of tide, but no currents, the "storm beaches" remain, and add to the extent of the land. The latter is very well seen in North Wales, along the coast line of Morecambe Bay, as also in other places.

[11] After very wet seasons great falls of the cliffs often take place; but until the debris is denuded away, few or no further falls will take place. The natives will often tell you that so many yards are going yearly, and in proof of this assertion will point to the waste of the previous winter, they supposing that the same happens every year. The greatest falls occur at the highest cliffs, on which account the greatest waste is supposed to be taking place in these localities; but after careful calculation I find this not to be the case. None of the high cliffs reach an average waste of ·75 ft. per annum, and generally the loss is less than ·5 ft., while in places the low cliffs have been denuded away as much as 2·5 feet per annum. The greatest denudation on the whole line of coast between Hook and Dalkey is at the low cliff near St. Patrick's Bridge, Kilmore.

and sea walls. This damage was not due to the direct force of the waves, but to other circumstances. In this county nearly all the piers and walls have vertical or nearly vertical faces, and at the time mentioned, on account of the greater height of the water, these faces caused waves to rise, that fell on and behind the piers, thus removing the coping stones, and in places breaking the structures. In some places the sea walls were similarly injured, while in others the water flowing over the walls cut away the backing, and gradually cut out breaches from the inside to the outside.

On January 3, 1877, there was on the east coast a very high tide, which along the Wicklow coast was accompanied by very moderate wind.[12] This did considerable damage to the Dublin and Wicklow Railway between Greystones and Wicklow; not so much by the direct force of the waves as by their height, they flowing over the line, and the overflow cutting into the land side of the embankment, thus gradually eating out the breaches. In no place did a breach commence at the outside.[13] This tide did not cause a "full" of the beach, although it pushed the margin higher and more inland than formerly. Between Newcastle and the Wicklow Chemical Works it encroached, in places, as much as three yards, into the Murrough (*anglice* sea plain); and the beach after the tide presented a gradual slope, having shingle and gravel to the margin of the old beach with fine sand in the new portion. Elsewhere along the east coast of Wicklow and Wexford this high tide did little damage. It invaded kitchen middens and such like accumulations in the vicinity of the towns, and floated out vast numbers of bottle corks, which in all cases were carried northward by the "flow" and stranded along the margin of the full tide.

During the last six years various experiments were made during the different stages of the tide, while the wind was blowing in different directions, as also when "ground swells" were coming in, to test the travelling of the beach, and also to discover what caused the "cutting out" of the beaches, and their filling in with white quartz pebbles about the size of hen eggs. The effects of each wave were noted; these, of course, cannot now be described in detail; we shall give only the general conclusions arrived at in regard to this portion of the east coast. We cannot do the same for the coast between Carnsore and the Hook, as the "counter-tides" there cause so many complications.

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[12] At Kingstown Pier, Co. Dublin, the wind was from the east at 8 A.M., with a force of 7, and veered to the S. S. E. by 6 P.M., gradually falling to a force of ·3.

[13] This nearly always is the cause of breaches in the steep-faced embankments so general in Ireland to protect the different intakes; they all fail from the water topping them and breaching them behind.

Summary of the General Effects of Tides and Winds on the East Coast between Carnsore and Dalkey.

W. and S.W. Winds

generate "ground swells." In places they drift the sand from the land out to sea, and on to the beaches.

S. Winds

in places cause "fulls" at the northern extremities of the strands, due partly to the banking up of the beach, and partly to the land driftage of sand. They often generate "ground swells."

S.E. Winds

carry away the southern end of the beaches, to fill them in at the northern. At Poulduff (Cahore), two strong twelve-hour gales are said to be sufficient to cut out the "fulls" south and north of the pier.

E.S.E. by E. to E.N.E. by E.

generally heap up the beaches. In places, however, on account of coming obliquely to the flow-tide current, they in part cut them out, forming transverse ridges on the beach, Fig. 4, Pl. 5. The first drives up sand, gravel, and stones, and strands them; while the second "licks" them out. To form this class of beach the wind waves are not as effective as the tidal currents, and the materials are more stranded than removed; so that while the wind lasts the strand fills.

N.E. Winds

cut out the northern portions of the strands, while they often "fill" the beach to the southward. The most remarkable "fulls" due to these winds are the previously-mentioned "fulls" to the S.W. of Kilmichael Point, the "fulls" in the strand near Wicklow, and in the strand near Bray. In the first locality, after the continuous winds from the north-eastward during the spring of 1876, a foreshore formed, in places over 200 yards wide, at the base of a cliff, where, during the previous winter, there was deep water.

N. Winds.

No direct influence of these winds was observed, except that they seemed to retard the flow of the tide up the Irish Sea.

Ground swells,

with the "flow-tide," usually "cut out." They sometimes form transversely-ridged beaches similar to those due to E. winds (Fig. 4, Pl. 5); but in such cases the cutting out is generally in excess.

At the beginning of the "ebb-tide," sometimes "cut out," especially near Courtown.

Ground swells—*continued.*

With E. winds, sometimes seem to assist in filling the beaches, but with N.E. winds they "cut out."

With the "counter-tides," "cut out" the beaches.

With the "half counter-tides," sometimes "fill in" the beaches.

The cutting out due to "ground swells" and contrary winds is different from that due to the S.E. winds; as the latter carry the beach forward, while the other suck out the beach into deep water. "Ground swells" due to S. winds break on the shore line nearly as quickly as ordinary wind waves; but the waves of the other "ground swells" have intervals of one, two, five, or more minutes between them; the latter are much larger than the wind or tidal waves, which may be breaking at the same time, rise much higher on the beach, and often at one sweep carry away a mass of material that it has taken a number of the small waves to pile up. Some of the big waves, or "rollers," that visit the coast on rare occasions, are due to earthquakes.

III. *The Carriage of large Stones in Deep Water.*

On the coast of Galway, in many of the small bays or strands, are beaches composed of very large, roundish shingle, many of the blocks weighing two or three cwt. and a few over a quarter of a ton. These beaches were found to be fuller after storms than at other times; many of the blocks were derived from rocks situated more or less to the southward of the beaches, and those blocks, in order to reach the positions in which they were, must have travelled through water fifteen or more fathoms deep. As, after storms, laminaria and other deep-water seaweeds were observed to be attached to the blocks most recently brought in, a series of observations were made during the calms. It was ascertained that, in places both in the bays and in the open sea, in water from twenty fathoms deep to low water of spring tides, there are variously-sized blocks scattered about irregularly on sandy bottoms; and on these seaweeds grow rapidly, some having leaves whose measured lengths were over twenty feet. It was also found that, when the leaves were full grown, the weeds made the stones buoyant; in some cases so much so that they were, during each "flow-tide," drifted from their places towards the shore. By other observations it was found that places which had been dotted over with stones, with sea weeds attached, were after storms free from them. This was ascertained by marking favourable spots on the chart, and visiting them as soon as possible, during low water, after a storm. Some of these stations were four miles from the coast line.

Mr. J. Chaloner Smith, M. Inst. C.E., pointed out to me a sandy strand, below the south end of the Bray shingle beach, which was supposed to be always free from blocks. Circumstances prevented me from making observations here, therefore I turned my attention to

a similarly circumstanced sandy strand at the west end of the Tacumshin Æolian sand ridges (Chart sheet, xiv.), which was visited during low water on April 4, 1876, after a heavy gale from the S.W. Section (Plate 5, Fig. 3) represents the form of the beach. Below, at the line of low water, there was nearly level, undisturbed fine sand; next above this was a slope of shingle, mixed with gravel and sand. At A and B, above and below the shingle slope, were lines of blocks with deep-seaweeds attached to them, and a few similar blocks were scattered over the slope, while they were very numerous on the nearly flat undisturbed sand, between B and C. As the tide rose, the blocks to which seaweed was attached began to travel landwards, although there was no wind, and only slight waves, due to a "ground swell." When visited twenty-four hours afterwards, not a block remained on the fine sand, and only a few on the shingle slope, they having been collected into horizontal lines at A and B. Subsequently this beach, as also others similarly circumstanced, were visited after storms, and in all cases the results were the same; as the large stones attached to deep-seaweeds were brought in, and in one or two tides sorted and arranged in lines, below and above the slope of the beach.

When discussing this subject with Mr. Thos. Winder, M. Inst. C.E., he mentioned that after he had ran out the Dover Breakwater into ten fathoms water, "pebbles, during storms, were carried round it, foundations opened were filled with sand and gravel, the pebbles usually not being larger than nuts, but sometimes as large as hen eggs; while rounded chalk flints, from the Shakespeare Cliff, were carried to the end of the breakwater"; also that a piece of iron plant, about 1·5 feet by 2 feet, and 1·5 inches thick, was, during a gale, blown off the stage, and carried about twenty feet to leeward, or about thirty feet from the end of the work, in water about ten fathoms deep. "I traced the track of it through the small thread-like seaweed, and my conclusions, as I stood on the sea-bed, were that the sea undoubtedly moves things which may fall upon, and stand above, the general sea-bed in depths of ten fathoms; although it does not move the fine and tender growth which my feet trod into the surface, and my hands easily pulled out of it."

During storms large stones, with deep-seaweed attached, are carried up on to St. Patrick's Bridge, near Kilmore, county Wexford, as also on to the tidal portion of the Long Bank off Ballygeary Bay. At the Kish Bank, off Dublin Bay, an attempt was made to erect a lighthouse on screw piles; but it was given up, as the flanges of the piles were broken by large blocks in the accumulation of sand. Such blocks were probably carried by seaweed to this shoal, as the shifting nature of which shows that it is the result of the action of the present sea, and not a submerged hill of boulder drift.

From the foregoing observations it would appear that large blocks can be drifted in considerable depths of water: not by the simple impulse of the currents or storm waves, applied directly to them, but by

that action, combined with the buoyancy given to the stones by the growth of the seaweed on them. Tidal currents of great depth, if there is sufficient weed attached to a stone, would, although slowly, yet gradually carry it into water of a sufficient depth to be influenced by storm waves, after which the driftage would be accelerated. In some cases I have observed that the buoyancy of the weeds attached was superior to the weight of small stones, and that the latter, when lifted from their sand bed, were at the mercy of the currents. Thus any stone, no matter what its size, if the buoyancy of the weeds attached exceeded its weight, may be drifted by a tidal current in any direction, no matter what depth the water between the place from which it first started to that at which it was finally stranded. In connexion with the growth of seaweed, it may be mentioned that at the Ballygeary pier, during the time the works were discontinued in 1877 till the resumption of operations in 1878, the divers found the foundations (consisting of bags of concrete), laid down the previous year, "overgrown by a thick forest of seaweed over eight feet in height."

IV.—*The Effects of the Travelling of the Beaches on the Harbours and Piers between Hook Point and Dalkey Island.*

The principal piers and harbours on the coast line between Hook Point and Dalkey Island are those at Kilmore, Ballygeary, Wexford, Poulduff (Cahore), Courtown, Arklow, Wicklow, Greystones, and Bray. All of these, except those at Wicklow and Greystones, are unsatisfactory on account of the driftage of the beaches, in addition to which there is at Courtown and Arklow the land sand driftage. The present state of these different harbours and piers seems due to there having been no allowance made for the travelling and the stoppage thereat of the beaches under the influence of the tidal currents and wind waves. Their condition suggests that in all such constructions, if it is possible to avoid it, no impediments should be placed in the line in which the beach naturally travels; also that the piers ought to be perpendicular to the coast line, and not curved; as those of the first class act similar to the headlands, and generate a "half counter-tide" a few hours before high water, which keeps sand from accumulating alongside them.

Kilmore Quay.—This is situated on the South Wexford coast, about half way between St. Patrick's Bridge and Crossfarnoge Point (Fig. 1, Pl. 6). The harbour is sheltered by the pier from the W. and S. W. winds, but it is open to S. E. and E. winds, and when these blow strongly the fishing boats have to be drawn into the "old boat harbour." The "flow-tide" driftage goes N. E. from the Saltees to the St. Patrick's Bridge, and from thence westward to Crossfarnoge; and, being stopped by the pier, it is rapidly silting up the harbour. The driftage of the beaches and the direction of the more prevalent and destructive winds being as described above, it would appear that the most advantageous situation for the quay would have been on St. Patrick's Bridge; while to protect the harbour from the S. and S. W.

winds a breakwater could have been erected in the strait between Crossfarnoge and the North Saltee. Such structures would have constituted a harbour protected from all bad winds, and at the same time would not have presented any obstacles to the free driftage past of the sands and beaches.

BALLYGEARY SHIP PIER.—This is now in course of erection. It is to consist of a pier in deep water, which is to be connected with the land by a viaduct. The shipping will have harbourage on the east side of the pier, while the beach can drift past under the viaduct and thence westward along the shore line. When it was commenced, a short land pier was run out to low water of spring tide, from which the viaduct should start: this land pier, however, acted as a groyne, and the small embayment to the east rapidly filled up. To this we will return hereafter in connexion with the description of groynes.

WEXFORD HARBOUR.—The shifting sands at the entrance into Wexford Harbour have been, from time immemorial, a source of annoyance and expense to the inhabitants of the town; but as that eminent engineer Sir John Coade, M. Inst. C. E., has lately reported on them, it would be presumptuous in me to make any remarks or suggestions about them.

POULDUFF QUAY (Cahore).—This was built for the convenience of the boats during the herring fishing, and for landing the cargoes of vessels during calm weather. It is a pier running out at right angles to the beach, and having in the centre of it a culvert to carry off the drainage from the Cahore flats; while at a little distance from the end of the pier, and connected to it by a wooden bridge, is a short breakwater (Fig. 2, Pl. 6). This has been a complete failure in every way, as north and south of the pier great "fulls" have collected, which not only prevent boats approaching the pier, but also have stopped the mouth of the culvert. As previously mentioned, the driftage south of Cahore Point moves northward, and after it passes the point it turns westward into the Poulduff beach, where it is stopped by the pier. N. E. winds cut the "full" to the north of the pier, but they are prevented from acting on the south "full" by that structure; and as long as the south "full" remains, the pier continues banked up; for as fast as the north "full" is cut out it is replenished from the south one. This pier is never clear, except after a storm from the S. E., which has caused both the south and north "fulls" to travel rapidly northward.

When the conditions of this locality are considered, it would appear that when the pier was first contemplated the site chosen for it ought to have been near Cahore Point. If it had been erected there it would not have interfered with the present driftage, while it would have given shelter to the boats from the S. and S.E. winds. Under present circumstances, the pier might be greatly improved by securing and making permanent the south "full." This could be

effected by piling, or a concrete wall along its margin.[14] If this were done, the north "full" ought soon to be carried away by the tidal driftage and the cutting out of the N. E. winds.

COURTOWN HARBOUR.—This has not been a successful undertaking. The work consists of two parallel piers leading to a small basin, into which the Owenavorragh has been conducted by a canal cut from Courtown House (Fig. 3, Pl. 6). Within and near the mouth of the harbour a bar accumulates, over which it is both difficult and dangerous to haul the boats except in calm weather.

None of the conditions of the locality seem to have been considered in laying out this harbour. As at Poulduff, so here also, the most advantageous site would have been near the point (Breanoge Head); besides, the two piers should not have been of equal length: it is in consequence of their being so that the nearly impassable bar is formed. The driftage and cutting out of the beach is similar to that at Poulduff, but the N. E. winds have little or no power between the piers to cut out the bar.[15]

There seem to be facilities for constructing, even under present circumstances, a good harbour in this locality for a coasting trade. But to do this the south "full" would have to be secured and made permanent by a retaining wall from Breanoge Head to the south pier: the latter should be lengthened into deep water by a stage similar to, but higher than, that which is now in ruins; while the north pier ought to be cut away, and the land driftage from the sandhill to the north prevented by a wall or trees. The retaining wall from Breanoge Head would prevent detritus accumulating on the south of the piers, to be carried by every "flow-tide" into the harbour mouth. A stage instead of a solid pier would not interfere with the driftage, while the cutting away of the north pier would give the N. E. winds full power of cutting out any bar that might accumulate.

Arklow Harbour is circumstanced somewhat similarly to Courtown Harbour. I hope to describe it fully elsewhere.

WICKLOW AND GREYSTONES HARBOURS.—At these localities the observations made were not sufficient to be of much value. At Wicklow the shingle beach does not travel far enough south to block the entrance. This seems to be due to the "half counter-tide" previously mentioned, which a few hours before high water runs from Bride's Head westward. It might have been expected, that as the head waters of the Vartry, which river here flows into the sea, were cut off some years ago to supply Dublin with water, some alteration would have since taken place in the condition of the bar at Wicklow

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[14] Piling fails on this coast on account of the worm; it is therefore not to be recommended.

[15] Some years ago the end of the north pier was carried away by a storm, and while it was in ruins the bar diminished, but since the pier was repaired the bar has been as bad as ever.

Harbour. Yet, as I have been informed, the river bar has not perceptibly changed since that time.

Bray Harbour has met with various disasters, which I have described in a Paper read before the Institute of Civil Engineers, Ireland.

V. *The Groynes on the Coast Line between Hook and Dalkey.*

ON no coast line are groynes so necessary as in that now under consideration, especially in parts of Wexford and Dublin where valuable land is yearly disappearing; yet they have been erected only in isolated spots.

Near Tacumshin Lake, on the south coast of Wexford, two small systems of groynes were made, to stop the inroads of the sea. These consist of a lateral barrier, from which short groynes extend to a little below high water-mark. These were most effective; the lateral barrier and the upper portions of the groynes stopping the land driftage of the Æolian sand, while the lower portion of the groynes pounded up the shingle beach: permanent ramparts are the result.

The landward portion of the Ballygeary Pier, although not intended as a groyne, has acted as such, and is an accidental proof of what great benefit would be derived from the construction of groynes on this coast line. In 1873, and previous years before the pier was commenced, "fulls" were formed on the beach line between Greenore and Rosslare Coastguard Station after continuous E. and N. E. winds; while at other times the "flow-tide" current sweeps the rocks clean at the base of the marl cliffs, thus leaving the latter open to the full force of the storm waves. In the spring of 1875, "fulls" accumulated between Greenore and the new pier during the E. and N. E. winds; and since then these have not been cut out, but, on the contrary, are gradually increasing. The small embayment to the east of the pier has been quite filled up, and now "sand-dunes" are gradually growing on it; while farther S. E. the rock section is almost concealed, and the denudation of the marginal marl cliff is gradually ceasing. This pier, or groyne, seems also to have had a beneficial effect on the marl cliffs to the westward of it. For, although the strands at the base of those cliffs appear very little fuller than formerly, yet their denudation seems to be gradually decreasing.

Here we may also mention other accidentally-formed groynes in the same neighbourhood. Formerly the *alva marina* was in great request, and the weed was carefully gathered. About the year 1876 the trade fell off, and the ungathered weed was carried by the tide and lodged in masses along the east end of the embankment of the North intake in Wexford Harbour. Previously to this the sea was cutting out and endangering the stability of the embankment, but the mass of seaweed formed a groyne against which masses of sand have since accumulated. In the winter of 1872–3 numerous large balks of drift timber were stranded on the Wexford coast. One of

these, a little south of the Blackwater, was floated in, during a spring tide, against the cliff, where it was fastened by a chain and left for over six months. During the time it was allowed to remain the land driftage collected against it a mass of Æolian sand, which has since become permanent, and has stopped the denudation of the cliff-line. Slips of the cliffs also form groynes, but only temporarily, as they are gradually cut away by the sea. Poulduff, Courtown, and Arklow piers have also acted as groynes, and to the southward of each of these are now considerable permanent accumulations.

On the coast of Wicklow, between the Kilcoole railway station and The Breaches, very effective groynes were constructed. These were erected under peculiar circumstances. The "flow-tide" current was rapidly cutting away the beach and endangering the railway; while the Company were restricted from making any works outside their boundary, a width of less than six yards, and any groynes placed inside such limits would extend only a short distance below high water-mark. They were, however, erected, the principal ones being over six feet high; and, although the circumstances seemed to be unfavourable, they filled rapidly, and formed a rampart that has stopped the encroachment of the sea.

At the north end of the Esplanade at Bray there is a system of groynes; but various circumstances have combined to make them ineffective. Their site was only a short distance south of the channel out of Bray Harbour; and the water from the river and estuary cut off the southward driftage of the beach to them, carrying it seaward, while the detritus that was beached on the south of the harbour channel was immediately carted away; thus much of the materials that should have filled the groynes never reached them. In addition to this, the groynes do not seem to have been judiciously planned or erected. They were constructed of round timber, driven down vertically; and in no place in Ireland have I found that round timber, driven down vertically, forms effective groynes. Furthermore, mid-way between the groynes extending from the coast-line, other short ones were placed, a little above low water-mark, and these generated currents which licked out all the shingle from between the land-groynes. The boundary pilings at the new baths on Bray Esplanade have acted as groynes, and have collected a considerable mass of shingle alongside of them.

XXXIV.—RESEARCHES ON THE PARALLAX OF 61 (A) CYGNI, MADE AT DUNSINK. By ROBERT S. BALL, LL. D., F. R. S., Andrews Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland.

[Read November 30, 1878.]

ON the 22nd of August, 1868, my predecessor, Dr. Brünnow, commenced a series of observations with the South Equatorial, at Dunsink Observatory, with the view of making a new determination of the annual parallax of 61 Cygni. The method he adopted was to observe the difference of declination between the following star (B) of 61 Cygni and a star of the 9–10 magnitude, which in 1868 followed in 51·5 secs. at a distance of 104″ to the north. These observations were repeated occasionally by Dr. Brünnow, and the last was made on the 24th of May, 1873. There are altogether twenty determinations of the difference of declination between the two dates I have mentioned.

After I had had some practice in the use of the South Equatorial, I recommenced the series of observations on the differences of declination between 61 Cygni and the following star, which Dr. Brünnow employed. But there is an important difference between my series of observations, as here recorded, and those made by Dr. Brünnow, to which I have already referred. In the latter case the *following* component (B) of 61 Cygni was used, while in my observations it is the difference in declination between the *preceding* component (A) and the small star following which has been observed. It will naturally be asked why I did not use the same component as Dr. Brünnow had done, and thus render the two sets of observations capable of being incorporated together. I confess that in the first instance this was due to an inadvertence on my part. I was at first under the impression that Dr. Brünnow had used the preceding star (A) of 61 Cygni, and under this impression I commenced my work by measuring the difference of declination between (A) and the small star following. It was not until I had made a large number of observations that I became aware the component I was using was not the same as that which Dr. Brünnow employed; and when this discovery was made, the question arose as to the best course to be adopted. I felt reluctant to discard the work I had already done, and recommence anew with the other component, and therefore I resolved to complete the series of measurements which I had commenced, and thus, in the first instance, to seek for a determination of the annual parallax from my own observations alone. At the same time, I decided to commence as soon as possible another series of observations which would be strictly in continuation with Dr. Brünnow's work. At the present date these observations have made considerable progress, but their reduction or discussion has not yet been commenced. It will therefore be under-

stood that in the present Paper these observations are not referred to, and that the value of the parallax now presented has been solely founded on the observations of the difference of declination between (A) and the small star following.

In adopting this course, I was also influenced by some other considerations. In the researches of Struve on the annual parallax of 61 Cygni, he employed the star (B), as Dr. Brünnow had done. It however appeared to me that on this very account a determination of the parallax in which the preceding star was used would be, if successful, of very considerable interest. As this was the first work of the kind in which I had engaged, I was glad to have an opportunity of the practice which it afforded, before I commenced a series of measures which were to be amalgamated with those obtained by the mature skill of my predecessor.

I have to regret that, owing principally to the exceedingly bad weather which prevailed here during the winter of 1877–8, the number of observations is not so large as I would have wished. The observations yield thirty-six equations of condition for the determination of the four unknown quantities on which the apparent difference of declination depend. These equations contain the results of observations made on thirty-five different nights, which are only tolerably well distributed over the twelve months during which the observations extend. The method of observing which I have used is almost identical with that employed by Dr. Brünnow in his researches on the parallax of 61 Draconis (*Observations and Researches at Dunsink*, Parts I. and II.). A complete observation of the difference of declination is the mean of eight independent determinations.

The observations were reduced by employing the values of the micrometer screws and the thermometric coefficients determined by Dr. Brünnow (Part I., p. 8). The results were then cleared from refraction by the application of the correction

$$+ kD \operatorname{cosec}^2 (\delta + m),$$

where D is the apparent difference of declination, δ is the declination of 61 Cygni, and m is the function of the hour angle defined in Bessel's Table, *Astr. Unt. Bd.* 1, p. 190, and computed here for the latitude of Dunsink (53° 23′ 13″).

To clear the observed difference of declination from the effects of precession, aberration, and nutation, and reduce the result to the date 1878·0, the following correction is applied:—

$$\begin{aligned}
&+ 0''\cdot05266\,(1878 - t) \\
&+ [6\cdot3089]\; i \\
&- [6\cdot4137]\; h \cos (H + a) \\
&+ [7\cdot5735]\; g \sin (G + a) \\
&+ [7\cdot3643]\; h \sin (H + a).
\end{aligned}$$

i, h, g, H, G, are the well-known constants in the Nautical Almanac; t is the year in which the observation was made; α is the right ascension of 61 Cygni.

In order to free the observations from the grosser part of the effects of the large proper motion of 61 Cygni, I have assumed that the small comparison star is at rest, and that the preceding star A has the annual proper motion assigned to it by Argelander, viz.:

$$+ 3''\cdot 232.$$

When these various corrections have been applied, the following are the values of the differences of declination:—

1877.			1877.		
July	3,	66″·879	Dec.	13,	67″·701
	6,	66 ·899		14,	67 ·474
	19,	66 ·739		17,	67 ·482
	22,	66 ·927		19,	67 ·326
	24,	66 ·901		29,	67 ·350
Aug.	4,	66 ·798		30,	67 ·553
	12,	66 ·867	1878.		
	31,	66 ·959	Jan.	31,	67 ·659
Sept.	3,	66 ·695	Mar.	24,	67 ·273
	21,	66 ·942		24,	67 ·433
	27,	66 ·897		31,	67 ·252
Oct.	1,	66 ·888	April	1,	67 ·001
	8,	67 ·304		17,	67 ·224
	16,	67 ·013		24,	67 ·161
	23,	67 ·195		27,	66 ·852
	25,	67 ·021	May	18,	66 ·851
	29,	67 ·369		28,	66 ·688
Nov.	2,	67 ·300	June	1,	67 ·341
	13,	67 ·344			

Assuming that the true mean value of the difference of declination is $67''\cdot 150 + x$, that the true relative proper motion of A and the comparison star is $3''\cdot 232 + x'$, that π is the annual parallax, and that k is the difference in the coefficients of aberration for the two stars, then the observations yield thirty-six equations, which, being solved in the usual manner, give

$$x = +\ 0''\cdot 0274 \pm 0''\cdot 0210$$
$$x' = -\ 0\ \cdot 0943 \pm 0\ \cdot 1218$$
$$\pi = +\ 0\ \cdot 4654 \pm 0\ \cdot 0497$$
$$k = +\ 0\ \cdot 0330 \pm 0\ \cdot 0493$$

I subjoin the various determinations of the annual parallax of

61 Cygni, which have been hitherto given (*see* Auwer's *Abhandlungen der Akademie zu Berlin,* 1868).

Bessel, first fourteen months, ...	0″·357
Bessel, last three months, and Schlüter, .	0 ·536
Johnson, first eleven months, ...	0 ·526
Johnson, last seven months, ...	0 ·192
Struve, ...	0 ·511
Auwers, ...	0 ·564

To these should be added the result obtained by Peters from zenith distance observations—

Peters, ...	0″·349

Auwers concludes, from his discussion of the whole subject, that the value of half a second is more likely to be correct than the smaller value which some of the observers have found. The new series of observations here described seem to support this view.

The complete details of these observations and their discussion are about to be published in Part III. of the *Dunsink Observations;* but I have thought that this brief account of the results might be of interest to the Academy.

XXXV.—NOTE ON THE APPLICATION OF LAGRANGE'S EQUATIONS OF MOTION TO PROBLEMS IN THE DYNAMICS OF A RIGID BODY. By ROBERT S. BALL, LL. D., F. R. S., Andrew Professor of Astronomy in the University of Dublin, and Royal Astronomer of Ireland.

[Read February 24, 1879].

THE problem to which I wish to direct attention occurs in the *Theory of Screws*, and is thus expressed in the language of that Theory.

A quiescent rigid body has freedom of the n^{th} order: being given the co-ordinates of an impulsive wrench, it is required to find the co-ordinates of the corresponding instantaneous screw.

The solution of this problem is given in the *Theory of Screws*, p. 60. The method there adopted is quite different from that now communicated, which is founded on Lagrange's *Equations of Motion in Generalized Co-ordinates.*

Without any loss of generality we may assume that the impulsive wrench is on a screw which belongs to the screw system, defining the freedom of the body; for, owing to the reactions of the constraints, one screw (but only one) can always be found in the screw system, a wrench on which would produce the same effect as a wrench on a screw otherwise placed.

Under these circumstances, let ζ_1, &c., ζ_n, represent the co-ordinates of the impulsive screw, and θ_1, &c., θ_n, be the co-ordinates of the corresponding instantaneous screw, reference being made as usual to the principal screws of inertia.

Lagrange's equations are typified by

$$\frac{d}{dt}\left(\frac{dT}{d\dot{\theta}_1}\right) - \frac{dT}{d\theta_1} = -P_1,$$

where T is the kinetic energy, and where $P_1\delta\theta_1$ denotes the work done in a twist $\delta\theta_1$ against the forces.

If ζ'' represent the intensity of the impulsive wrench, then

$$P_1 = 2p_1\zeta''\zeta_1$$

$$T = M(u_1^2\dot{\theta}_1^2 + \&c. + u_n^2\dot{\theta}_n^2),$$

where p_1, p_2, &c., are the pitches of the principal screws of inertia,

61 Cygni, which have been hitherto given (*see* Auwer's *Abhandlun*
der Akademie zu Berlin, 1868).

Bessel, first fourteen months, ...	0″·357
Bessel, last three months, and Schlüter, . .	0 ·536
Johnson, first eleven months, ...	0 ·526
Johnson, last seven months, ...	0 ·192
Struve, ...	0 ·511
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distance observations—

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I have thought that this brief account of the results might be
rest to the Academy.

, u_n, certain constants pertaining to those screws
pon the mass of the body and its freedom.
e, therefore,

$$\frac{d}{dt}(Mu_1^2\dot{\theta}_1) = -\zeta''p_1\zeta_1,$$

ce, ntegrating during the small time t,

$$Mu_1^2\theta_1\dot{\theta} = -\zeta_1 p_1 \int_0^t \zeta'' dt;$$

so that θ_1, &c., θ_6, are proportional respectively to

$$\frac{p_1\zeta_1}{u_1^2}, \text{ \&c., } \frac{p_n\zeta_n}{u_n^2}.$$

XXXVI.—OBSERVATIONS IN SEARCH OF STARS WITH A LARGE ANNUAL PARALLAX. By ROBERT S. BALL, LL.D., F.R.S., Royal Astronomer of Ireland.

[Read December 9, 1878.]

IN continuing the researches made by my predecessor Dr. Brünnow, on the Parallax of Stars, I have adopted two different classes of observation. The first of these is the ordinary continuous series of observations of two or three specially chosen objects extending over an entire year. This is, no doubt, the only method by which a parallax amounting to a small portion of a second can be detected, much less accurately measured. It is, however, to be observed, that as a set of measures takes at least an hour to complete, it is almost impossible for the most assiduous observer to have more than three stars in hand at the same time. I have, therefore, adopted the course of having two stars in regular observation at the same time, and of devoting whatever other opportunities I may have to the system of observations which will be described in the present Paper. The full details of the observations here referred to will shortly appear in Part III. of the *Dunsink Observations*.

It is, of course, well known that up to the present no parallax has been detected which exceeds a single second of arc. In the great majority of cases the parallax is very much less, even if it be appreciable. But when we reflect that not one star out of every ten thousand has yet been regularly examined for parallax, it is obvious that it would be in the highest degree rash to conclude that there are no stars nearer to us than any of those of which we already know the distance.

In selecting objects appropriate for investigation of annual parallax, astronomers have generally chosen those stars which are exceptional, either on account of their brilliancy, or the largeness of their proper motions. The presence of these exceptional features in a star is doubtless a *prima facie* presumption that the star is comparatively near us. On the other hand, it cannot but be observed that the brightest star (*i.e.* Sirius) appears to have a parallax of only $0''\cdot232$,[1] while for the star Groombridge, 1830, which has the enormous proper motion of $7''\cdot05$ annually, Brünnow has found a parallax no greater than $0''\cdot090$. The presumptions of nearness founded on great brilliancy or great proper motion can hardly be said to be justified by the results of observation.

[1] From Houreau's invaluable *Répertoire des Constantes de l'Astronomie* I extract the following :—" Jacq. Cassini, by the method of absolute altitudes in 1717, found a parallax of $6''$ for Sirius. Piarri, by the same method, in 1805 reduced this to $4''$. Henderson, in 1840, from the meridian altitudes at the Cape, found the value $0''\cdot23$. Gyldén, in 1864, from the altitudes found by Maclear, at the Cape, in 1836-7, deduced a parallax of $0''\cdot193$. Abbe, in 1868, from the altitudes at the Cape, in 1856–1863, deduced the parallax $0''\cdot273$. A mean of the three last determinations is the value given above."

The question then arises as to whether there are any additional presumptions which may guide the parallax seeker in choosing the stars to observe. I will mention two.

In Mr. G. J. Stoney's memoir on the "Physical Constitution of the Sun and Stars," *Proceedings of the Royal Society*, No. 105, 1868, p. 49, is the following passage:—

"The minute crimson stars which are met with here and there in the sky seem to be either very small stars or stars enormously distended by heat. It is very desirable that the proper motion and parallax of these bodies should be inquired into when practicable, on the chance that some of them may be found to owe their colour to being very small, and therefore very close to us."

There is also a certain presumption that some of the variable stars are really small, and that therefore, as we see them, they must be comparatively near us.

Before commencing the observations now about to be described, a working list was formed, containing Red Stars, variable stars, stars with large proper motion, and several other stars which were chosen on different grounds. The observations of these stars are directed with the special object of seeing whether any of them have a large parallax. My present purpose is to place on record the observations of forty-two different objects selected from this working list. In almost every case here described the observations have been sufficient to convince me that the parallax is *certainly less than one second of arc, and most probably does not exceed half a second*. It will, therefore, be understood that the results of the reconnoitring observations which are here set forth are merely negative so far as the immediate object in view is concerned; and as they do not suggest the existence of any parallax worth following up, I do not intend to observe the objects herein named any further. The time, therefore, seems to have arrived when these observations may be published.

We have now to describe the principle upon which the reconnoitring observations have been conducted. The effect of annual parallax upon a star is to make the apparent place of the star describe a minute ellipse, of which the mean place of the star occupies the centre. In the reconnoitring observations the star is observed twice; at the first observation the star is at one of the extremities of the major axis of the ellipse. The second observation is made after an interval of six months, during which time the star has moved to that part of the ellipse which is at the other extremity of the major axis. It thus appears that the two observations are so arranged that in each case parallax shall have the greatest effect it is capable of producing.

When a star undergoes the greatest displacement from parallax it must be at a distance of 90° from the sun. If, therefore, α, α', and δ, δ', be the right ascension and declension of the star and the sun, respectively, then, at the time of greatest parallactic displacement,

$$\tan\delta \tan\delta' = -\cos(\alpha' - \alpha).$$

By the aid of this formula the working list was arranged. For a given date the values of a', δ' are known, and the above formula gives a relation between a and δ. Taking lengths proportional to a, δ as abscissæ and ordinates, respectively, twenty curves were plotted on a plane corresponding to dates uniformly distributed over the year. These curves, of course, agree in passing through the point which corresponds to the pole of the ecliptic. By the aid of these curves, when the right ascension and declination of an object are known, it is easy to see at a glance when the object is 90° from the sun. The two critical dates were thus found for each of the objects in the working list, and the observations were always made as nearly as possible at these critical dates.

The instrument employed was the South Equatorial, with the Pistor and Martin's micrometer. The mode of observation was almost identically that adopted by Dr. Brünnow in his observations of α Lyræ and its companion (see *Dunsink Observations*, Part I.). The following is the method by which the observations have been reduced, and the different corrections applied:—

We shall denote the two stars by S, S', the two wires of the micrometer by I, II, and the two possible positions of the micrometer by A, B: then, the expression, AIS', for example, denotes the reading of the screw I. when placed upon the star S', the micrometer having the position A. A complete measure of the distance of the two stars is obtained by placing one wire on each star, reading off the screws, then interchanging the wires, and reading again. A complete series of measures consists of four such pairs, two being taken in the position A, and two in the position B. Each of the four complete measures are computed separately, the two first by the formula

$$\frac{r_1}{2}(AIS - AIS') + \frac{r}{2}(AIIS' - AIIS).$$

the two last by the formula

$$\frac{r_1}{2}(BIS' - BIS) + \frac{r_2}{2}(BIIS - BIIS'),$$

r_1, r_2 denote the values of a revolution of screws I., II., respectively. expressed in seconds of arc. These values have been computed from the expressions found by Dr. Brünnow—

$$r_2 = 1{\cdot}001337\, r_1,$$
$$r_1 = 8''{\cdot}9927 - 0''.0002922\,(\tau - 50°),$$

where t is the temperature Fahrenheit. In each observation the temperature is read off upon a thermometer, which, for convenience, is screwed to the finder of the telescope, the bulb of the thermometer being sixteen inches distant from the eye-piece of the telescope. For convenience in reducing the observations a table is used, which gives $\log r_1 - \log 2$ and $\log r_2 - \log 2$ for each degree.

The direction of the daily motion, or the "parallel," was determined as follows:—Wire I was set to the middle of the field, the

micrometer was turned, approximately, to the right position, and clamped; the driving clock was set in motion, and the star was brought by the slow motions to coincide with the intersection of I and the fixed wire. The clock was then stopped, and the micrometer was adjusted by the tangent screw so that the star ran along the fixed wire. In a second observation care was taken that the tangent screw was turned the opposite way when making the final adjustment. The observations of position were then made, and at the close of the series two more observations of the parallel were made, with the same precautions as before, but with the micrometer 180° from its position in the first set. The mean of the four observations was adopted as the "parallel." On referring to the observations, it will be seen that on many occasions the set of parallel observations was not so complete as is here described. Such care in determining the parallel as is necessary when the stars are three or four minutes apart would, of course, be thrown away if the stars were comparatively close together.

In observing the position, the micrometer was turned until the fixed wire was placed over the two stars, and the final adjustment was made with the tangent screw. This observation was then repeated, the head of the screw being turned the opposite way on the second occasion. The micrometer was then turned through 180°, and two more observations were made, with similar precautions. Thus, a complete determination of the position angle involves four readings of the parallel and four of the position.

The observations thus made have to be corrected for the effects of refraction, aberration, precession, and nutation. We shall consider them separately.

Let D be the distance of the two stars, and let p be the position angle; then, if z be the zenith distance, η the parallactic angle, and k the coefficient of refraction, the correction to be applied to the apparent distance for refraction is

$$kD\,(1 + \tan^2 z \cos^2 (p - \eta)),$$

where k is the coefficient of refraction taken from Bessel's Tables, *Ast. Unt.* Bd. I., p. 198. To facilitate the calculation of z and η, the table suggested by Bessel has been computed, which gives the values of m, and log cot n for each minute of hour angle in the latitude of Dunsink, 53° 23′ 13″. We can then readily compute z and η from the formulæ—

$$\tan \eta = \cot n \sec (\delta + m),$$

$$\tan z = \sec \eta \cot (\delta + m).$$

In using these expressions it is supposed that eastern hour angles are negative; cot n has the sign of the sine of the hour angle, and m has the sign of the cosine of the hour angle.

In applying the correction for refraction to the observation of the position angle, it is, of course, to be remembered that the reading of

the parallel is also affected by refraction: we have thus the expression

$$3438\ k \tan^2 z \cos p \sin (2\eta - p)$$

to denote the correction expressed in minutes of arc, which is to be applied to the observed position angle in order to clear it from the effects of refraction.

The distance of the two stars is also affected to a certain extent by aberration. The correction to be applied to the observed distance is

$$D \sin 1'' (i \sin \delta - h \cos (H + a) \cos \delta),$$

where i, h, H, are given in the *Nautical Almanac* for the day in question. When this correction has been applied to the observed distance of the two stars, we obtain the distance between the mean places of the two stars for the preceding 1st January.

The position angle of the two stars is also affected by aberration, and the correction to be applied, expressed in minutes of arc, is

$$-\frac{h}{60} \sin (H + a) \tan \delta.$$

On account of the motion of the pole, arising from precession and nutation, there is a corresponding change in the direction of the parallel, and therefore a change in the position angle; the correction

$$-\frac{g}{60} \sin (G + a) \sec \delta$$

will make the position angle what it would have been when referred to the position of the pole on the preceding January 1. The quantities g, G, are those given in the *Nautical Almanac* for each day.

As the observations are all reduced to the epoch January 1st, 1875, a further correction,

$$-0{\cdot}3342\ (t - 1875) \sin a \,.\, \sec \delta,$$

must be applied to the position angle observed in the year t.

Corrections must also be sometimes applied on account of the differences between the proper motions of the two stars. Let

$$(t - 1875)\ \Delta a \text{ and } (t - 1875)\ \Delta\delta$$

be the corrections arising from the proper motions of the principal star relatively to the other star, which must be applied to the right ascension and declination of the principal star to bring the place to the date, January 1st, 1875. Then, the correction to be applied to the distance is

$$\cos p\Delta\delta\ (1875 - t) + \cos \delta \sin p\Delta a\ (1875 - t),$$

while the correction to be applied to the minutes of the position angle is

$$3438 \sin p \frac{\Delta\delta}{D} (1878 - t) - 3438 \cos \delta \cos p \frac{\Delta a}{D} (1875 - t).$$

By the application of these several corrections, the observed distance and position angle of the two stars is transformed into the true distance and position angle when the stars are situated in their mean positions on 1st January, 1875.

The following catalogue contains the results of these observations for forty-two different objects selected from the working list, of which the construction has been already explained. The first column of the catalogue contains the number of the object for convenience of reference. The second column gives the designation of the object. Frequent reference is here made to the list of Red Stars compiled by Schjellerup (Vierteljahrschrift der Astronomischen Gesellschaft IX. Jahrgang). This catalogue is referred to by the abbreviation "Schj." (Red). In other cases (as, for example, No. VI.) the reference (+ 27°, 1270) is, as usual, to the "Durchmusterung," vols. iii., iv., v., of the *Bonn Observations*. No. XXXI. is a Red Star from Mr. Birmingham's Catalogue (*Transactions* of the Royal Irish Academy, vol. xxvi., pp. 249–354).

The third column gives the date of the observation, which is always as near as possible to one of the two critical dates already referred to. In connexion with these critical dates, it is to be remembered that they have been chosen without reference to the comparison star, and therefore are not generally the precise dates at which parallax would make the maximum derangement of either the distance or the position angle. They are only the dates at which the star is situated at the apses of the parallactic ellipse. If the comparison star happened to be situated in the direction of the minor axis of the parallactic ellipse, there would be no parallactic change in the distance at the two dates, but there would be the greatest change possible in the position. On the other hand, if the comparison star were situated on the major axis of the parallactic ellipse, there would be the greatest change possible in the distance. It might, no doubt, have been better, in some respects, to have chosen the dates so that absolutely the maximum alterations of distance and position should have been secured, but this would have involved more time than I cared to devote to work which might probably lead only to a negative result. This method would, generally, have required five observations. The first of these would be devoted to the selection of a suitable comparison star, and a determination of its place; then, from these results the four dates of maximum and minimum derangement of distance and position, respectively, would have been determined, and the observations would have to be renewed at or near these dates. I have, therefore, adopted the simpler method, which only requires two observations, these being generally about the dates when the star is at its greatest distance on one side or the other of its mean place.

The fourth column gives the corrected distances, and the fifth column contains the corrected values of the position angles.

No.	Object.	Date.	Corrected Distance.	Corrected Position.
I.	Schj. (red), 3, . .	12 Aug., 1877, 31 Jan., 1878,	183″·733 183 ·079	316° 5′ ·76 316 15 ·87
II.	Schj. (red), 3 *a*, .	1 Aug., 1876, 12 Jan., 1877, 19 Dec., 1877,	91 ·286 91 ·336 91 ·560	68 34 ·64 68 11 ·00 67 53 ·44
III.	Schj. (red), 28, .	17 Feb., 1877, 31 Aug., 1877,	332 ·919 332 ·135	236 6 ·45 235 37 ·80
IV.	Schj. (red), 29, .	20 Feb., 1877, 31 Aug., 1877,	229 ·778 229 ·801	85 16 ·90 85 10 ·26
V.	Schj. (red), 64, .	9 Oct., 1876, 5 April, 1878,	263 ·831 263 ·677	191 49 ·17 191 32 ·33
VI.	+ 27°, 1270, . .	28 Mar., 1877, 1 Oct., 1877,	169 ·368 169 ·163	218 50 ·85 218 44 ·05
VII.	+ 25°, 1594, . .	28 Mar., 1877, 27 Sept., 1877, 11 Oct., 1877,	105 ·799 105 ·985 105 ·873	87 11 ·30 87 8 ·93 86 59 ·18
VIII.	53 Geminor, . .	5 April, 1877, 16 Oct., 1877,	209 ·359 208 ·886	315 46 ·93 315 52 ·76
IX.	Schj. (red), 94 *a*, .	5 April, 1877, 16 Oct., 1877,	100 ·363 100 ·170	182 40 ·56 182 27 ·34
X.	+ 28°, 1532, . .	27 Mar., 1877, 13 Nov., 1877,	242 ·772 243 ·248	293 20 ·83 293 27 ·28
XI.	+ 28°, 1532, . .	27 Mar., 1877, 13 Nov., 1877,	185 ·079 185 ·056	345 4 ·02 345 24 ·61
XII.	Schj. (red), 115, .	25 Nov., 1876, 27 Nov., 1876, 17 April, 1878, 21 April, 1878,	183 ·888 184 ·758 183 ·638 183 ·565	226 0 ·57 226 16 ·27 225 32 ·70 225 37 ·31
XIII.	Schj. (red), 120, .	7 May, 1877, 17 May, 1877, 10 Dec., 1877,	122 ·463 121 ·752 122 ·602	170 15 ·80 170 2 ·94 170 41 ·00
XIV.	R. Leonis = Schj. (red), 123,	27 Nov., 1876, 8 Dec., 1876, 12 Dec., 1876, 17 May, 1877,	258 ·247 258 ·374 258 ·708 257 ·719	268 20 ·64 268 33 ·20 268 26 ·44 268 25 ·19
XV.	R. Leonis = Schj. (red), 123,	27 Nov., 1876, 14 Dec., 1876, 17 May, 1877,	275 ·722 276 ·120 274 ·241	224 32 ·44 224 41 ·80 224 37 ·59

	Object.	Date.	Corrected Distance.	Corrected Position.
	ıj. (red), 146, .	22 Dec., 1876, 5 May., 1878,	276″·699 276 ·391	108°43′·18 108 33 ·45
	ıj. (red), 155, .	14 Dec., 1876, 8 June, 1877,	196 ·436 195 ·508	49 15 ·42 49 10 ·45
	Schj. (red), 156, .	8 Jan., 1877, 12 June, 1877,	393 ·856 392 ·083	344 15 ·94 344 3 ·56
.x.	Schj. (red), 163, .	12 Jan., 1877, 16 June, 1877,	271 ·843 271 ·888	240 6 ·09 232 52 ·94
	Schj. (red), 163, .	12 Jan., 1877, 16 June, 1877,	59 ·275 58 ·510	158 31 ·89 158 30 ·90
XXI.	+ 15°, 2891, . .	18 Feb., 1877, 1 Aug., 1877, 28 Aug., 1877,	131 ·406 130 ·854 131 ·079	45 16 ·06 45 4 ·13 45 15 ·85
XXII.	Schj. (red), 182, .	9 Jan., 1877, 16 Feb., 1877, 29 July, 1877,	391 ·615 392 ·353 390 ·977	341 1 ·31 340 52 ·42 341 3 ·54
XXIII.	Schj. (red), 185, .	4 Mar., 1877, 17 Mar., 1877, 2 Aug., 1877,	75 ·799 75 ·509 76 ·297	49 35 ·47 49 21 ·36 49 31 ·24
XXIV.	Schj. (red), 186, .	4 Mar., 1877, 2 Aug., 1877,	132 ·579 132 ·807	9 32 ·86 9 2 ·11
XXV.	+ 46°, 2194, . .	28 Feb., 1877, 30 Aug., 1877,	133 ·974 133 ·683	91 18 ·26 91 45 ·20
XXVI.	Schj. (red), 199 *a*,	16 Sept., 1876, 4 April, 1878,	288 ·433 287 ·352	291 9 ·06 290 7 ·70
XXVII.	Schj. (red), 211 (*a*),	17 Mar., 1877, 1 Oct., 1877,	165 ·101 164 ·866	143 49 ·73 143 3 ·07
XXVIII.	+ 23°, 3316, . .	27 April, 1878, 27 Sept., 1877,	209 ·621 209 ·660	317 55 ·96 318 8 ·02
XXIX.	+ 24°, 3400, . .	21 Sept., 1877, 24 April, 1878,	263 ·065 262 ·570	260 45 ·06 260 35 ·46
XXX.	+ 24°, 3405, . .	6 April, 1877, 21 Sept., 1877,	128 ·481 127 ·989	221 51 ·15 222 6 ·31
XXXI.	+ 36°, 3168, . .	16 Oct., 1877, 21 April, 1878,	134 ·311 134 ·778	355 14 ·81 354 31 ·55
XXXII.	Schj. (red), 221 (*a*),	14 Oct., 1876, 17 May, 1877,	168 ·227 169 ·291	12 40 ·68 12 11 ·35

No.	Object.	Date.	Corrected Distance.	Corrected Position.
XXXIII.	Schj. (red), 221 (*a*),	14 Oct., 1876, 17 May, 1877,	122″·059 121 ·394	121° 27′ ·33 121 40 ·57
XXXIV.	Schj. (red), 225, .	23 May, 1877, 8 Oct., 1877, 5 May, 1878,	48 ·677 47 ·832 48 ·386	82 32 ·26 82 59 ·95 —
XXXV.	+ 22°, 3660, . .	7 May, 1877, 3 Sept., 1877,	255 ·704 256 ·231	254 44 ·96 254 40 ·47
XXXVI.	+ 35°, 3985, . .	25 May, 1877, 6 Nov., 1877,	58 ·693 58 ·623	97 14 ·85 97 29 ·52
XXXVII.	+ 35°, 4001, . .	17 Nov., 1876, 17 Nov., 1876, 4 May, 1877, 25 May, 1877,	60 ·430 61 ·497 62 ·019 61 ·418	330 6 ·20 330 5 ·40 329 47 ·31 330 1 ·93
XXXVIII.	+ 35°, 4001, . .	17 Nov., 1876, 25 May, 1877,	86 ·466 86 ·546	182 10 ·68 181 35 ·05
XXXIX.	τ Cygni, . . .	15 Nov., 1876, 25 May, 1877, 12 June, 1877,	185 ·576 185 ·788 186 ·338	78 12 ·88 78 24 ·42 78 37 ·70
XL.	Schj. (red), 244, .	29 Nov., 1876, 19 May, 1877,	124 ·265 123 ·652	8 10 ·20 7 34 ·88
XLI.	+ 41°, 4114, . .	12 Dec., 1876, 27 May, 1877, 15 June, 1877,	211 ·521 211 ·614 211 ·434	97 2 ·32 97 10 ·24 97 10 ·39
XLII.	+ 41°, 4117. . .	27 May, 1877, 15 June, 1877, 7 Nov., 1877,	211 ·095 210 ·923 211 ·286	67 40 ·43 67 45 ·15 67 51 ·31

It then became necessary to sift these observations with the view of seeing whether they afford any traces of parallax. A discrepancy between the distances or positions at the dates of the two observations must be attributed either, firstly, to the accidental errors of observation; or, secondly, to the proper motion of one or both of the two stars; or, thirdly, to the parallax of one or both of the two stars; or, fourthly, to the joint effect of various causes. It will be convenient, in considering the effect of parallax upon the position angle, to eliminate the effect of the distance by multiplying the actual correction to the position angle by the sine of the distance. If π be the parallax, and if the effect of parallax upon the distance be $\pi \cos \theta$, then the effect of parallax upon the position angle will be $\pi \sin \theta$. It follows that, when the object is observed at the apses of its paral-

he discrepancy between the two distances will be $2\pi \cos \theta$,
pancy between the two position angles will be $2\pi \sin \theta$.
es cannot be both less than $\pi\sqrt{2}$. If, therefore, we
ussion every case in which the discrepancy in the two
he two position angles, amounts to a single second of
in which the parallax could amount to 0″·70 will be
ded. On examining the list of observations, it will be
venty-seven cases there is not a discrepancy, either in
position or in the distance, which amounts to a single
c. In these cases there is, therefore, no suggestion that
reaches anything like the limit named: if any appreciable
sts, it is masked in the errors of observation, which are,
e, under little control when the number of observations is so

re, however, fifteen cases in which the discrepancy does
second of arc. Thus, so far as the distance is concerned,

xv.	the discrepancy is	1″·7
xviii.	,,	1 ·8
xxii.	,,	1 ·0
xxvi.	,,	1 ·1
xxxii.	,,	1 ·1

The following are the cases in which the discrepancy in the two position angles is at least equivalent to a second of arc:—

iii., v., xi., xii., xiii., xviii., xxiv., xxv., xxvi., xxvii., xxxi., xl.

In the case of xviii. and xxvi., we have a discrepancy amounting to over a second both in the distance and the position angle.

It may be remarked, that of these fifteen cases a large proportion will be found where the observations have been more or less incomplete, and where, consequently, the errors of observation may reasonably be expected to be greater than in the cases where the observations are complete. We shall, however, inquire as to how far the discrepancies are capable of being subdued or removed by the supposition of annual parallax. For this purpose it will be necessary to examine the effect of annual parallax on each of the objects, separately, by the well-known formulæ. In order to reduce the observed distance between a star which has parallax π, and an adjacent star which has no parallax, to the distance, as seen from the sun, a correction must be applied equal to

$$- m\pi R \cos (\odot - M),$$

where R is the distance from the sun to the earth, and where $\odot$ is the sun's longitude, m, M being constants depending upon the object.

The corresponding correction to be applied to the position angle of the star which has no parallax, measured from the star which has parallax, is

$$- m'\pi R \operatorname{cosec} D \cos (\odot - M'),$$

where D is the distance of the two stars. The four quantities, m, m', M, M', have been computed from the well-known formulæ.

It is also sometimes useful as a check to calculate the effect of parallax on the distance and position by the other method, which is, indeed, much shorter than the general method just referred to, when only one or two observations have to be reduced.

Let α', δ', be the right ascension and declination of the sun at the time of the observation, then th[illegible] e are computed:—

$$\rho \cos \sigma = \sin \delta', \qquad [illegible]' \sin (\alpha' - \alpha),$$

$$\rho \sin \sigma = \cos (\alpha' - \alpha), \qquad [illegible] \sigma + \delta).$$

The correction to the distance i[illegible]

$$+ \pi R [illegible]$$

The correction to the positi[illegible]

$$+ \pi R \lambda \text{ co}[illegible]$$

t of the calculations is given in the following Table :—

	Object.	Date.	Apparent Distance Corrected for Annual Parallax π.	Apparent Position Corrected for Annual Parallax π.
	(red), 28, . .	1877. Feb. 17,	332″.919 + 0″.921 π	236° 6′ .45 + 3′.61 π
		„ Aug. 31,	332 .135 − 0 .914 π	235 37 .80 − 3 .73 π
	j. (red), 64, . .	1876. Oct. 9,	263 .831 − 0 .227 π	191 49 .17 − 11 .60 π
		1878. April 5,	263 .677 + 0 .231 π	191 32 .33 + 11 .82 π
	- 28°, 1532, . . .	1877. Mar. 27,	185 .079 + 0 .451 π	345 4 .02 − 15 . 5 π
		„ Nov. 13,	185 .256 − 0 .341 π	345 24 .61 + 15 . 3 π
.	Schj. (red), 115, .	1876. Nov. 25,	183 .888 − 0 .455 π	226 0 .57 − 14 . 5 π
		„ „ 27,	184 .758 − 0 .448 π	226 16 .27 − 14 . 3 π
		1878. April 17,	183 .638 + 0 .497 π	225 32 .70 + 15 . 8 π
		„ „ 21,	183 .565 + 0 .504 π	225 37 .31 + 16 . 0 π
.	Schj. red), 120, .	1877. May 7,	122 .463 − 0 .420 π	170 15 .80 + 25 . 6 π
		„ „ 17,	121 .752 − 0 .368 π	170 2 .94 + 24 . 0 π
		„ Dec. 10,	122 .602 + 0 .206 π	170 41 .00 − 21 . 0 π
XV.	R Leonis, . . .	1876. Nov. 27,	275 .722 − 0 .406 π	224 32 .44 − 10 . 9 π
		„ Dec. 14,	276 .120 − 0 .356 π	224 41 .80 − 9 .75 π
		1877. May 17,	274 .241 + 0 .434 π	224 37 .59 + 11 . 4 π
XVIII.	Schj. (red), 156, .	1877. Jan. 8,	393 .856 − 0 .552 π	344 15 .94 + 6 .83 π
		„ June 12,	392 .083 + 0 .710 π	344 3 .56 − 6 .09 π
XXII.	Schj. (red), 182, .	1877. Jan. 9,	391 .615 − 0 .829 π	341 1 .31 + 4 .40 π
		„ Feb. 6,	392 .353 − 0 .559 π	340 52 .42 + 7 .08 π
		„ July 22,	390 .977 + 0 .710 π	341 3 .54 − 6 .36 π
XXIV.	Schj. (red), 186, .	1877. March 4,	132 .579 + 0 .519 π	9 32 .86 + 24 .97 π
		„ Aug. 2,	132 .807 + 0 .162 π	9 2 .11 − 24 .94 π
XXV.	+ 46°, 2194, . . .	1877. Feb. 28,	133 .974 + 0 .982 π	91 18 .26 + 0 .64 π
		„ Aug. 30,	133 .683 − 0 .999 π	91 45 .20 − 1 .85 π
XXVI.	Schj. (red), 199 (*a*),	1876. Sept. 16,	288 .433 + 0 .926 π	291 9 .06 − 4 .47 π
		1878. April 4,	287 .352 − 0 .732 π	290 7 .70 + 7 .32 π
XXVII.	Schj. (red), 211 (*a*),	1877. Mar. 17,	165 .101 + 0 .644 π	143 49 .73 − 15 .67 π
		„ Oct. 1,	164 .866 − 0 .531 π	143 3 .07 + 17 .65 π
XXXI.	+ 36°, 3168, . . .	1877. Oct. 16,	134 .311 − 0 .187 π	355 14 .81 − 25 . 0 π
		1878. April 21,	134 .778 + 0 .306 π	354 31 .55 + 24 . 2 π
XXXII.	Schj. (red), 221 (*a*),	1876. Oct. 14,	168 .227 − 0 .393 π	12 40 .68 − 18 . 7 π
		1877. May 17,	169 .291 + 0 .817 π	12 11 .35 + 12 . 6 π
XL.	Schj. (red), 244, .	1876. Nov. 29,	124 .265 − 0 .565 π	8 10 .20 − 21 . 4 π
		1877. May 10,	123 .652 + 0 .524 π	7 34 .88 + 23 . 9 π

In the great majority of cases these results pronounce emphatically against the supposition of a parallax large enough to be detected amid the errors of observation which are inseparable from the method which has been adopted. In no case do they afford reliable indications of a parallax large enough to be detected by the method of reconnoitring.

XXXVII.—SPECULATIONS ON THE SOURCE OF METEORITES. By ROBERT S. BALL, LL.D., F.R.S., Royal Astronomer of Ireland.

[Read January 13, 1879.]

I HAVE recently read M. G. Tschermak's most interesting memoir "Die Bildung der Meteoriten und der Vulcanismus."[1] I am not competent to offer any opinion on the mineralogical questions involved in his discussion, but the numerous arguments he has advanced appear to me to justify his conclusion, that "the meteorites have had a volcanic source on some celestial body." These arguments are briefly as follows:—

Meteorites are always angular fragments, even before they come into our atmosphere.

Most meteoric irons have a crystalline structure, which, according to Haidinger, requires a very long period of formation at a nearly constant temperature. This condition could only have been fulfilled in a large mass.

Many meteoric stones show flutings resembling those seen on terrestrial rocks, and which are due to the rubbings of adjacent masses.

Other meteorites have a structure produced by the union of several fragments, so as to be analogous to breccia.

Many meteorites are composed of very small particles analogous to volcanic tufas.

After glancing at the old theory of the volcanoes in the moon, and rejecting as untenable the hypothesis that meteorites have any connexion with the ordinary shooting star showers, Tschermak concludes, "We may suppose that many celestial bodies, of considerable dimensions, are still small enough to admit of the possibility that projectiles driven from them in volcanoes shall not return by gravity. These would really be the sources of meteorites." Similar views having been put forward by Mr. J. Laurence Smith and other authorities, it seems not unreasonable to discuss the following problem:—

If meteorites have been projected from volcanoes, on what body or bodies in the Universe must these volcanoes have been located?

Let us first take up a few of the principal celestial bodies *seriatim*, and consider their claims to the parentage of the meteorites. We begin with the sun. It has been shown that there exists upon the sun tremendous explosive power. It is not at all unlikely that the power would be sufficiently great under certain circumstances actually to drive a body from the sun never to return. We might, therefore, find upon the surface of the sun adequate explosive power for the volcano, but the projectiles are here the difficulty. There are a

[1] Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften, Wien, 1875. Band lxxi., Abtheilung 2, pp. 661-674.

number of circumstances (notably the breccia-like appearance of some meteorites) which show conclusively that the meteorites have been torn from rocks which were already nearly, if not quite, solid; and as it seems in the highest degree improbable that rocks of this nature should exist in the sun, we may conclude that the sun has not been the source of the meteorites.

Can the meteorites have come from the moon? Owing to the small mass of the moon, the explosive power requisite to carry a body away from the moon may no doubt be comparatively small; but can a body which has been projected from a volcano in the moon tumble upon the earth? *To simplify questions of this kind we shall suppose various disturbing influences absent.* We shall suppose that the projectile is discharged from the moon with sufficient velocity to carry it completely therefrom. We shall then omit all account of the disturbing influence both of the sun and the moon on the projectile, and we shall suppose that the projectile is really revolving round the earth as a satellite. This projectile will fall upon the earth if its distance from the earth's surface when in perigree be less than the radius of the earth (augmented perhaps by the thickness of the earth's atmosphere). It should, however, be observed, that *if the projectile once escaped the earth, it would never fall thereon;* hence the question as to whether the moon can be the source of the meteorites now falling appears to be connected with the question as to whether the lunar volcanoes are now active. But it is generally believed that the lunar volcanoes are not now active to any appreciable extent (even if the suspected indications of recent change were thoroughly established). It follows, that even if the moon has been a source of meteorites in ancient times, we no longer receive a supply from that quarter. There is, of course, just a possibility that projectiles from the moon in past ages, which have hitherto escaped collision with the earth, may, under the influence of the *disturbing causes previously excepted*, occasionally fall to the earth as a meteorite.

Passing from the sun and the moon, let us now bring under review some of the other celestial bodies, and see how far they will fulfil the conditions of the question, Is it possible that the meteorites can have been projected from the surface of a planet? In order to get over the difficulties of the great initial velocity which would be necessary to overcome the gravitation of a large planet, it seems natural to inquire if a volcano placed upon one of the small planets could accomplish the task.

It is clearly impossible that a projectile from any source should ever fall on the earth, unless the orbit of the projectile cuts the plane of the ecliptic in the narrow ring, something over 8000 miles wide, which the earth and its atmosphere trace out on the ecliptic; but if a meteorite with an elliptic orbit round the sun intersect this ring, then in the lapse of time it may happen that the earth and the meteorite will meet at the point where their orbits intersect; the meteorite will then fall upon the earth, and its long travels will be at an end.

We shall therefore consider the circumstances under which it would be possible for a volcano on one of the minor planets (for example, Ceres) to discharge a projectile so that the projectile shall intersect the ecliptic in the ring we have just referred to. As the mass of the planet is small, the initial velocity which would be required to carry a projectile away from the planet presents no difficulty, perhaps an ordinary cannon would be sufficient, *so far as the mere gravitation to the planet is concerned.* But when we consider that the projectile must be driven through the ring we have been considering, a vastly more powerful instrument would be required.

Ceres is moving in an orbit (supposed circular and in the ecliptic) with a velocity of about eleven miles per second. A projectile discharged from Ceres will have an actual velocity which is compounded of the velocity of Ceres, with the velocity which is imparted by the volcano. But simple dynamical considerations show that if the projectile have an initial velocity *perpendicular to the radius vector*, differing much from eight miles per second, it can never intersect the ring, no matter in what direction it be discharged.[2] The volcano on Ceres must therefore be adequate to the abatement of the velocity perpendicular to the radius vector from eleven miles per second to eight miles per second, *i.e., the volcano must be at the very least adequate to producing an initial velocity of three miles per second.* As this is quite independent of the additional volcanic power requisite to carry the projectile away from the attraction of Ceres, it is obvious that after all there may be but little difference between the volcano which would be required on Ceres, and that (of six-mile power) which would project a body away from the surface of the earth for ever.

Admitting, however, that a volcano of sufficient power were placed upon Ceres, would it be likely that a projectile driven therefrom would ever cross the earth's track? This is a question in the theory of probabilities, and it is not easy to state the problem very definitely. If the *total* velocity with which the projectile leaves the orbit of Ceres be less than eight miles per second, then the projectile will fall short of the earth's track; on the other hand, if the *total* initial velocity exceeds sixteen miles per second, the orbit in which the projectile moves will be hyperbolic, and though it may cross the earth's track once, it will never do so again. Taking a mean between these extreme velocities we may investigate the following problem:—Suppose that a projectile is discharged from a point in the orbit of Ceres in a *random* direction with the *total* initial velocity of twelve miles per second, determine the probability that the orbit of the projectile shall cross the earth's track. When this problem is solved in accordance with the calculus of probabilities, it is found that the chances against the occurrence are about 50,000 to 1, *i.e.*, out of every 50,000 projectiles discharged at random from a point in the orbit of Ceres, only a single one can be expected to cross the earth's track.

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[2] Disregarding an obvious exception.

It is thus evident that there are two objections to Ceres (and the same may be said of the other minor planets) as a possible source of the meteorites. Firstly, that notwithstanding the small mass of Ceres, a very powerful volcano would be required; and secondly, that we are obliged to assume that for each meteorite which could ever fall upon the earth, at least 50,000 must have been ejected.

It thus appears that if the meteorites have been originally driven from any planet of the solar system, large or small, the volcano must, from one cause or another, be a very powerful one.

There is, however, one planet of the solar system which has a special claim to consideration. On that planet it is true that a volcano would be required which was capable of giving an initial velocity of at least six miles per second; but *every* projectile launched from that volcano into space would, after accomplishing an elliptic orbit round the sun, dash through the track of the earth, and again pass through the same point at every subsequent revolution. It is not here a case of one solitary projectile out of 50,000 crossing the earth's track, but every one of the 50,000 possesses the same property. The planet of which we are speaking is, of course, the earth itself. If in ancient times there were colossal volcanoes on the surface of the earth which had sufficient explosive energy to drive missiles upwards with a velocity sufficient to carry them away from the earth's surface, after making allowance for the resistance of the air, these missiles would then continue to move in *orbits round the sun*, crossing at each revolution the point of the earth's track from which they were originally discharged. If this were the case, then doubtless there are now myriads of these projectiles moving through the solar system, the only common feature of their orbits being that they all intersect the earth's track. It will, of course, now and then happen that the earth and the projectile meet at the point of crossing, and then we have the phenomenon of the descent of a meteorite. The theory, that the meteorites have originated in the earth, was, so far as I know, first put forward by Dr. Phipson. Mr. J. Lawrence Smith, in a letter I received from him some months ago, inclines to the same view as at all events one of the probable sources.

It is well to note here the great diffierence between the lunar theory of meteorites and the terrestrial theory. For the lunar theory to be true it would probably be necessary that the lunar volcanoes should be *still* active. In the terrestrial theory it is only necessary to suppose that the volcanoes on the earth *once* possessed sufficient explosive energy. No one supposes that the volcanoes on the earth at present eject the fragments which will constitute future meteorites, but it seems probable that the earth may be now slowly gathering back in these quiet times the fragments she ejected *in an early stage of her history*.

Assuming, therefore, that the meteorites have had a *quasi*-volcanic origin on some considerable celestial body, I am led to agree with those who believe that most probably that body is the earth.

XXXVIII.—AN EASY MODE OF OBTAINING THE COMPLETE DIFFERENTIAL EQUATIONS OF MOTION OF AN OCEAN SURROUNDING A SOLID NUCLEUS, AND SUBJECT TO ANY DISTURBING FORCES (THE NUCLEUS ITSELF REVOLVING ON A FIXED AXIS); WITHOUT CALCULATION OR TRANSFORMATION OF CO-ORDINATES; FROM SIMPLE GEOMETRICAL AND MECHANICAL PRINCIPLES. By the REV. SAMUEL HAUGHTON, M.D., Dubl.; D.C.L., Oxon.

[Read April 14, 1879.]

THE complete differential equations of the motion of the sea or atmosphere, referred to polar co-ordinates, are regarded, justly, as one of the most brilliant results that we owe to the genius of Laplace; and yet they are found to be a "stumbling-block" in the way of young mathematicians, from the hideously repulsive form in which they are deduced, by transformation, from fixed rectilinear co-ordinates, by Laplace himself, and by his followers.

Any attempt, therefore, to write down these equations at sight, from elementary geometrical and mechanical principles, will be regarded as useful.

According to the self-evident principle of D'Alembert, all problems of Dynamics are reducible to problems of Statics, by introducing velocities and accelerating forces, equal and opposite to the existing velocities and accelerating forces.

Now, the most general equations of equilibrium, of any system, are the following, six in number—

$$\begin{aligned} X = 0, \quad Y = 0, \quad Z = 0, \\ L = 0, \quad M = 0, \quad N = 0, \end{aligned} \tag{1}$$

where X, Y, Z, are the sums of the external forces resolved along three rectangular axes; and L, M, N, are the sums of the Couples (or Twists) of those forces round the axes of X, Y, Z, respectively.

The corresponding dynamical equations are—

$$\begin{aligned} X - \frac{d^2x}{dt^2} &= 0, \\ Y - \frac{d^2y}{dt^2} &= 0, \\ Z - \frac{d^2z}{dt^2} &= 0, \\ L - \frac{d}{dt}\left(z\frac{dy}{dt} - y\frac{dz}{dt}\right) &= 0, \\ M - \frac{d}{dt}\left(x\frac{dz}{dt} - z\frac{dx}{dt}\right) &= 0, \\ N - \frac{d}{dt}\left(y\frac{dx}{dt} - x\frac{dy}{dt}\right) &= 0. \end{aligned} \tag{2}$$

These equations become, in the case of an incompressible fluid—

$$\frac{dp}{dx} = X - \frac{d^2x}{dt^2},$$

$$\frac{dp}{dy} = Y - \frac{d^2y}{dt^2}, \qquad (3)$$

$$\frac{dp}{dz} = Z - \frac{d^2z}{dt^2},$$

where p is the common pressure of the fluid (equal in all directions) at any point (x, y, z).

It will be noted, that the last three equations of (2), depending on couples, disappear; because, in consequence of the mobility of the particles of the fluid, *inter se*, internal couples or twists become impossible.

The Laplacian equations of motion, in polar co-ordinates, are usually deduced from (3), by transformation of the co-ordinates, from x, y, z, referred to fixed axes, where the axis of x is the axis of rotation; that of y an axis perpendicular to x, and fixed in space; and that of z, an axis perpendicular to those of x, y; to r, θ', ϕ', where r is the radius vector, θ' is the north polar distance, and ϕ' is the angular distance from the plane of x, y, of the meridian of any moving particle.

Instead of referring the forces to fixed co-ordinates, I refer them to the following moveable rectangular co-ordinates:—

Axis of x'.

Let R denote the sum of the forces at any point, acting along the radius vector (*negative* towards the centre, and *positive* from it.)

Axis of y'.

Let S denote the sum of the forces at any point acting in the meridional moving plane, and perpendicular to r (*positive* towards the equator, and *negative* towards the pole.)

Axis of z'.

Let T denote the sum of the forces at any point acting perpendicularly to the two former directions, or in the direction of the tangent to the small circle of latitude (*negative* against the rotation, and *positive* with it.)

Let r, θ', ϕ', denote the polar co-ordinates in their most general form. The alteration in pressure produced by a change in r is similar to that produced by a change in x, y, z, of the first three of equations (2) (because they are all linear magnitudes), and denotes a *force* acting to or from the centre; but the alteration in pressure produced by a change in angular direction by a change in θ' or ϕ' is no longer

a *force*, but a *couple*, tending to turn the fluid round the centre. Thus,

$\frac{dp}{dr}$ is a *force* acting in the direction of the radius vector;

$\frac{dp}{d\theta'}$ is a *couple*, acting always in the moving meridional plane, and whose axis moves perpendicular to that plane;

$\frac{dp}{d\phi'}$ is a *couple*, acting always round the axis of rotation, and parallel to the equatorial plane.

It is evident that if D'Alembert's equations (2) are satisfied—

1°. For *forces* acting along the radius vector;
2°. For *couples* acting in the meridional plane in every possible position of that plane;
3°. For couples acting always round the axis of rotation;

complete Dynamical Equilibrium will be secured.

We may discount all the mechanical consequences of the rotation by introducing the centrifugal force, leaving only the geometrical consequences of the rotation, in the problem.

The geometrical effect of the rotation is expressed by writing

$$\phi' = nt + \phi',$$

where n is the angular velocity of the earth's rotation.

The components of the velocity of any particle along R, S, T, are—

$$\frac{dr}{dt}, \quad r\frac{d\theta'}{dt}, \quad r\sin\theta'\left(n + \frac{d\phi'}{dt}\right).$$

The centrifugal force affects the directions R, S, only, and does not enter into T.

The centrifugal force in the direction of R is, obviously,

$$\frac{\frac{r^2d\theta'^2}{dt^2} + r^2\sin^2\theta'\left(n + \frac{d\phi'}{dt}\right)^2}{r}.$$

From this, and from the first three equations (2) we find, at sight—

$$\frac{dp}{dr} = R - \frac{d^2r}{dt^2} + \frac{rd\theta'^2}{dt^2} + r\sin^2\theta'\left(n + \frac{d\phi'}{dt}\right)^2. \qquad \text{(A)}$$

The centrifugal force in the direction of S is, obviously,

$$r \sin \theta' \cos \theta' \left(n + \frac{d\phi'}{dt}\right)^2.$$

The sixth of equations (2) therefore becomes, remembering

$$y' \frac{dx'}{dt} - x' \frac{dy'}{dt} = r^2 \frac{d\theta'}{dt},$$

and equating couples in the meridional plane—

$$\frac{dp}{d\theta'} = Sr - \frac{d}{dt}\left(r^2 \frac{d\theta'}{dt}\right) + r^2 \sin \theta' \cos \theta' \left(n + \frac{d\phi'}{dt}\right)^2.$$

If we now equate the couples in the equatorial plane, we
since

$$z \frac{dy}{dt} - y \frac{dz}{dt} = r^2 \sin^2 \theta' \left(n + \frac{d\phi'}{dt}\right),$$

$$\frac{dp}{d\phi'} = Tr \sin \theta' - \frac{d}{dt}\left(r^2 \sin^2 \theta' \left(n + \frac{d\phi'}{dt}\right)\right).$$

The three equations just found from elementary principl
exact equivalents of the Laplacian differential equations, whi
thus expressed by Airy[1] :—

$$\frac{dp}{dr} = X\frac{x}{r} + Y\frac{y}{r} + Z\frac{z}{r} - \frac{1}{2r}\frac{d^2(r^2)}{dt^2} + \frac{1}{r}\left(\frac{dr}{dt}\right)^2 + r\left(\frac{d\theta'}{dt}\right)^2 + r \sin^2 \theta' \left(n + \frac{d\phi'}{dt}\right)^2,$$

$$\frac{dp}{d\theta'} = - X\sqrt{y^2 + z^2} + \frac{Yxy + Zxz}{\sqrt{y^2 + z^2}} - \frac{d}{dt}\left(r^2 \frac{d\theta'}{dt}\right) + r^2 \sin \theta' \cos \theta' \left(n + \frac{d\phi'}{dt}\right)^2,$$

$$\frac{dp}{d\phi'} = Zy - Yz - 2r\frac{dr}{dt} \sin^2 \theta' \left(n + \frac{d\phi'}{dt}\right) - 2r^2 \sin \theta' \cos \theta' \frac{d\theta'}{dt}\left(n + \frac{d\phi'}{dt}\right) - r^2 \sin^2 \theta' \frac{d^2\phi}{dt^2}$$

[1] "Tides and Waves," p. 264.

It is to be remarked, that of the two examples thus described, the one is a vertical form in a trachyte rock, whilst the other is a horizontal form in a basalt; moreover, its direction is connected with that of the basalt dykes of the district.

M. Regnault attributes the cause of the forms to alterations of the rock mass, with accompanying exfoliation, but does not examine the question whether the rock was or was not originally homogeneous, and how far the absence of homogeneity in the basaltic and trachytic masses, and the consequent different rates of cooling and solidification which must have depended on that absence of homogeneity, induced subsequent jointing along certain lines.

Now, no mass of molten or fluid matter when in movement, and in contact with bodies differing from it in temperature and in composition, can remain quite homogeneous or have all its parts equally warm, and therefore, so long as it remains fluid and in movement, there must be a tendency to the formation of a more or less regularly banded structure, which would guide and even assist subsequent alteration of the rock, particularly by the action of water.

It is upon these considerations that I propose to base an explanation of the cylindrical form in question.

When columnar basalt is carefully examined on the cross section, lines or bands of structure may be frequently observed, generally parallel to the sides of the block, but not unfrequently whorl-shaped or wavy. This structure may be mainly due to hydration, but it may also be connected with the original fluid state of the mass, and with the relative rates of solidification of the different parts. We have as an example the flow-lines in large masses of cut glass.

As regards the basalt of the north of Ireland, we have every reason to assume that they came up to surface in the joints resulting from previous dislocation, and thence spread into and on the adjacent rocks. Those joints traverse rocks of various constitutions, representing lavic, crystalline, and sedimentary series. These rocks vary amongst themselves, as regards thickness, constitution, and states of aggregation. They were differently affected by the force having produced the joint; and it is but reasonable to assume that the joint varied in outline according to the nature of the rocks traversed.

When, therefore, the basaltic dyke mass was fluid and in movement, it was continuously in contact with those containing rocks, and was acted upon by them in three ways:—

1. By the cooling of the basaltic fluid, from the sides towards the central axis, and the consequent tendency to banded structure thus induced.

2. By the mechanical derangement of the conditions of regular flow, wherever an enlargement or a contraction occurred in the section of the joint, and by the retardation of the flow along the walls.

3. By the chemical reactions taking place between the fluid mass and such beds as were capable of being acted upon.

ne time there passes through the wall (2, 4) the quantity

$$+ \frac{dz}{d\theta'} d\theta' \Big) \times r^2 d\phi' \, dt \times \left(v \sin \theta' + \frac{d\,(v \sin \theta')}{d\theta'} d\theta' \right).$$

rence of these quantities is

$$\theta' \, d\phi' \, dt \left(z \sin \theta' \frac{dv}{d\theta'} + zv \cos \theta' + v \sin \theta' \frac{dz}{d\theta'} \right),$$

is equivalent to

$$r^2 \sin \theta' \, d\theta' \, d\phi' \, dt \left(\frac{d(vz)}{d\theta'} + vz \cot \theta' \right). \qquad (b)$$

e sum of (a) and (b) is the excess of inflow or outflow, in the dt, through the four walls of the trapezoidal prism. Now, as the m of the sea is fixed and allows no inflow or outflow, the sum of) must be equal to the area of the trapezoid, multiplied by or fall of the surface (taken with its proper sign).
s volume will be

$$r^2 \sin \theta' d\theta' d\phi' \, dt \times u. \qquad (c)$$

Hence, adding (a), (b), and (c) together (with a proper sign for u), we obtain

$$u + \frac{d\,(wz)}{d\phi'} + \frac{d\,(vz)}{d\theta'} + vz \cot \theta' = 0. \qquad (D)$$

This is Laplace's famous Equation of Continuity, and is identical with that given by him (*Méc. Cel.*, vol. i. p. 104), when the notation is changed into his notation.

Equation (D) may be thus written:—

$$u + z \left(\frac{dw}{d\phi'} + \frac{dv}{d\theta'} + v \cot \theta' \right) + \left(w \frac{dz}{d\phi'} + v \frac{dz}{d\theta'} \right) = 0.$$

The second part of this equation vanishes when the sea has a constant depth; in which case the Equation of Continuity reduces to the form

$$u + \delta \left(\frac{dw}{d\phi'} + \frac{dv}{d\theta'} + v \cot \theta' \right) = 0, \qquad (D)$$

where δ is the constant depth of the sea.

Every conceivable problem, in tidal motion and oceanic current circulation, is theoretically solved by equations A, B, C, and D; and the only further difficulties are practical, arising from the imperfection of our mathematical knowledge.

XXXIX.—ON A CYLINDRICAL MASS OF BASALT EXISTING AT CONTHAM HEAD, MOON BAY, COAST OF ANTRIM. By JOSEPH P. O'REILLY, C. E., Central School of Paris; Professor of Mining and Mineralogy, Royal College of Science for Ireland. Plates 8 and 9.

[Read May 12, 1879.]

WHEN engaged in studying the forms of columnar basalt at the Giant's Causeway, I had occasion to observe and to take sketches of a very remarkable cylindrical form of that rock, which occurs at the N. W. point of Moon Bay, marked Contham Head on the Ordnance Map, and situated at about two miles distance east of the Giant's Causeway.

When first observed by me in 1875, I was quite unable to explain its origin and connexion with the containing rock; but having subsequently revisited the locality, for its further examination, and the making of a few sketches, I was enabled to arrive at certain conclusions as to the nature and origin of this remarkable form, which I beg leave to submit to the Academy.

Contham Head is a small promontory or spit of basaltic rock, extending out into the sea about 250 feet, its breadth at the water level being about 200 feet. There is a central rib rising above the underlying basalt bed, about twenty to thirty feet at most, having a length of about 150 feet, and a breadth of about fifty feet.

This low, narrow, and relatively short promontory is only accessible from the cliffs by a narrow and precipitate pathway, used principally by the kelp-gatherers, but decidedly uninviting for those not accustomed to such ground. Such a point, quite out of the usual track of tourists, is but rarely visited, and I should not have had any knowledge of it had I not chanced to observe the remarkable cylindrical form when passing quite close to the shore in a boat, catching thus the bold outline presented by the eastern side of the rock form.

The cylindrical mass, known among the boatmen as the "*mill-stone*," occurs at the point of the promontory where the narrow spit joins the mainland. It here extends across the spit in an E.–W. direction, having a horizontal length of about fifty to sixty feet.

The section is not quite circular, being rather oval. The greater diameter, the horizontal one, is about twenty-four to twenty-five feet, and the vertical one about eighteen to twenty feet. It presents a series of apparently concentric joints, irregularly distributed as regards distance from the centre, and is furthermore broken up by radial jointing, also irregularly placed, and giving rise to blocks of forms very similar to those observable at the Causeway. The mass rests upon and is partially enclosed by an amygdaloidal basalt of the rich violet colour so remarkable in many of the beds along the coast, and characterized by the presence of masses of scarlet jasper wherever in contact with the sea water. This amygdaloidal basalt is much corroded, and is being

XL.—Notes of some Observations on Nitrification. By Edmund W. Davy, A. M., M. D., Professor of Forensic Medicine, Royal College of Surgeons, Ireland, etc.

[Read, May 12, 1879.]

A good deal of attention, on the part of chemists, has of late been given to the subject of nitrification, or the formation of nitrites and nitrates under different circumstances. This has arisen, in a great measure, from the observations of MM. Schlœsing and Müntz,[1] which were laid before the Academy of France about two years ago. From the researches of those gentlemen, they arrived at the conclusion that nitrification was due to an organised ferment, and that it was probably the office of some of the low forms of vegetable life to produce those oxides of nitrogen under different circumstances. And the subsequent investigations of Warrington, Storer, and of other chemists, would appear to go far to confirm the correctness of their theory of nitrification, at least under the conditions in which their experiments were made. Though there exists, no doubt in many cases, an intimate relation between the formation of nitrites and nitrates, and the development of certain organized germs, still as far as my observations go, I do not think that there is sufficient proof to show that their development in such instances is the cause of nitrification, and not, rather, one of the circumstances attendant on that process.

My experiments, however, were made not with a view to determine that question, but in reference to the detection of animal impurities in potable waters, and to ascertain the circumstances which were favourable or otherwise to the formation of nitrites and nitrates in waters which were so polluted, as the presence of such salts is generally regarded as indicating previous sewage contamination, and the drinking of water with such pollution is not only injurious to the health of those who thus employ it, but there exist strong grounds for the opinion which is now very generally entertained, that such water frequently becomes the means of conveying the germs of certain formidable diseases, especially those of typhoid fever and cholera, from its containing the fecal and other emanations of individuals labouring under those maladies, and thus disease and death are often insidiously brought into many homes when such diseases are prevalent in different localities.

Besides, as the formation or production of nitrates is one of great industrial and agricultural importance, any facts which might directly or indirectly enable us to facilitate or hasten that process would be of much practical value.

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[1] "Comptes Rendus," lxxxiv. 301.

As human urine and feculent matters may justly be regarded as the most offensive and dangerous ingredients of sewage in general, my experiments have been confined to those matters, and were principally made on urine, which, from its containing different nitrogenous substances, readily susceptible of decomposition, is peculiarly suited for the study of the nitrification of animal matters. By mixing this liquid with various proportions of water, and placing the mixtures under different circumstances, I have endeavoured to ascertain those that were favourable or otherwise to their nitrification; and to determine some points connected with that process which required further investigation. I should here observe that in detecting the occurrence of nitrification I have principally used the well-known test of Price for nitrites, which consists in adding to the water or mixture a thin solution of starch, containing a little iodide of potassium, and acidifying with diluted sulphuric acid, when a blue reaction from the liberated iodine will be immediately produced, should a very minute quantity of a nitrite be present. And as there is every reason to suppose that the production of nitrites precedes that of nitrates in the nitrification of organic matters in solution, and the detection of the former is much more easily effected than the latter, at least under the conditions existing in my experiments, I was satisfied in most cases to obtain the evidence of the formation of nitrites by the employment of the test to which I have just referred.

The experiments of Warrington[2] have led him to conclude that darkness is an essential condition to the development of those low forms of vegetable life, which are supposed in many instances to give rise to nitrification.

This is a question which it is difficult to determine decisively one way or the other, owing to the impossibility of having with us continuous daylight to operate with. Still I think we may arrive at an approximative conclusion on this point, by making comparative experiments on similar mixtures, kept altogether excluded from the light, and on those exposed to its full influence, and then determining the amount of nitrification which had taken place in each, after a given time; and if darkness be so essential to that process, we should naturally expect that in the mixtures exposed to its continuous influence there would be an earlier and a greater development of nitrification, than in those which had been placed under it for about one-third or one-half the time, each day of twenty-four hours.

From the results of several comparative experiments made in this way, I have come to the conclusion that the conditions of light or darkness exercise but little influence one way or the other in this process, at least under the circumstances existing in my experiments,

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[2] "Journal of the Chemical Society," January 1878.

which consisted in placing different portions of the same mixtures in similar bottles, some of which were surrounded with black cloth or velvet to exclude light, whilst others were left uncovered, and all of them were suffered to remain open or uncorked. On examination after a few days there was but little difference as to the amount[3] of nitrification that had taken place in each—indeed in some of my experiments it had progressed to a greater extent in the uncovered than in the covered bottles; and in all made on this subject (except those to determine this point as to the necessity or not of darkness), the mixtures were left exposed to the light, and some to the full influence of strong sunshine, yet still a considerable amount of nitrification took place in each. Besides, in nature much of the nitrates which occur in the surface soils of different localities must have been formed under the influence of more or less daylight; all of which facts, I conceive, are more or less opposed to the necessity of darkness in this process.

Another point which has not, I believe, been clearly established, at least as regards nitrification occurring in water containing organic matters, is the necessity of having a certain amount of air or free oxygen to carry on the process; this I have proved in the following very simple manner:—To water which had been kept boiling for some time to expel its contained air, I added a small quantity of freshly voided urine (the proportion employed being about one part of urine to sixteen parts of water, such a mixture having been proved to be very suitable for nitrification), and then repeated the boiling to ensure the removal, as far as possible, of any dissolved air. Several bottles which had been kept immersed in the boiling mixture were then filled completely with it, corked, and sealed with sealing-wax, to prevent the access of air. Some, however, of them containing this mixture were left open for comparison. After leaving the bottles for a day or two in the same place, I first examined the open ones for nitrites, and when the test indicated the abundant formation of those salts, I opened one of those sealed, when not a trace of nitrites was discoverable in its contents; the remaining sealed ones were opened at different periods subsequently, with the same results. Other comparative experiments were made, where the temperature of the mixtures was artificially kept at a heat very favourable to nitrification, but, in every instance where the access of air had been excluded, no trace of nitrites could be detected—clearly proving the necessity of more or less air or free oxygen for their formation. But the amount necessary to commence, at least, the process is small, for I found where

[3] In ascertaining the amount of nitrification, the indigo process as described by Sutton in his "Volumetric Analysis" was employed, which served for the determination of the nitrites and nitrates collectively; and though it may not be quite so accurate as some other methods, was sufficiently so for this purpose, as it was only the comparative amounts of nitrites and nitrates formed under the different circumstances of the experiments that I wanted to determine.

xture had not been boiled previously to the complete filling, g, and sealing of the bottles, that the air dissolved in the was sufficient to cause the production of nitrites to some

quantity of animal matter which is held in solution in the I find exercises a considerable influence over nitrification; for it occurs in very large proportion, there the process either does e place at all, or is carried on much slower than in the more solutions. This I have proved by comparative experiments ater mixed with different proportions of the same sample of or of solution of excrementitious matter, where I found that ation occurred first in the more dilute mixtures; and that where as much organic matter present, that the nitrites which might ely be formed soon afterwards disappeared again by their ent change or decomposition, whereas those that had been d in more dilute solutions have remained unchanged for a rable time.

the circumstance which I have found to exercise the greatest e over nitrification is that of temperature; for I have observed cold weather it is very slow in taking place, whilst in warm ich quicker, and that by the application of artificial heat the can be greatly accelerated. The correctness of this observa- borne out by the well-known fact, that it is from the soils of t hot climates that we obtain our chief supply of nitrates.

to what may be the most favourable temperature for this pro- have not yet been able to determine, owing to the difficulty, as rcumstanced, in maintaining continuously the same degree of l heat; but I have found that where the mixtures were placed hey were kept at a temperature which varied from about 70° F., that there, the process was carried on very quickly, and trites were soon abundantly formed, whereas in similar mix- aintained at lower degrees of heat, or at the ordinary tempera- ot a trace of those salts could be detected in the same time, t their presence was not discoverable till after a much longer

foregoing observations have, I conceive, some important bear- regards the contamination of water with sewage, and the evi- of such, derivable from the occurrence in it of nitrites and . For though the presence of those salts is undoubtedly in stances an indication of previous sewage pollution, still their , taken by itself, cannot be relied on as a sure indication of the of the water from such contamination. For the circum- present may have either been unfavourable to the formation tes and nitrates, or have produced their subsequent rapid dis- nce—thus, for instance, the lowness of the temperature of the ay have prevented their formation, or the quantity of organic present may have interfered with their development, or have their subsequent change and disappearance. Such, amongst

other circumstances influencing the presence of those salts in water containing animal matters, will at once be evident; and their absence, unless accompanied by other indications of purity, cannot be relied on as a proof of the freedom from such contamination.

Before I conclude, I wish to call attention to another fact, which I have noticed in connexion with this subject, viz., the rapidity with which nitrites are sometimes formed in waters contaminated with sewage impurities. This is a subject of considerable importance in an analytical point of view, as I shall endeavour briefly to explain.

It is well known by those who have analysed potable waters, that the method which chemists now principally employ to ascertain their purity or otherwise is to determine the quantity of ammonia a given amount of the water will yield on distillation, both before and after the addition of a strongly alkaline solution of permanganate of potash. The first obtained is termed the free, and the second the albuminoid ammonia. The former is regarded as the representative of the nitrogenous organic matters previously existing in the water, which have undergone more or less decomposition, whilst the latter is produced by the action of the alkaline permanganate on those substances still present in the water. Consequently, the less of each that is furnished by a sample of water when so treated, the purer organically is it regarded, and the safer, other circumstances being similar, would it be for potable purposes. When lately analysing a sample of water that had been contaminated with sewage, to ascertain the amount of such pollution, which was afterwards the subject of an important legal inquiry, in my first trial I found that the water yielded a quantity of free ammonia which was equivalent to 0.970 parts of a grain per gallon, but, on repeating the determination a few days afterwards, it was discovered that it had fallen to 0.186 parts of a grain for the same quantity of water, or to less than one-fifth of the former amount; whereas the quantity of albuminoid ammonia yielded had slightly increased. This result as to the great decrease of free ammonia, which at first rather surprised me, I ascertained was due to the formation of nitrites, which had been developed to a large extent, in so short a time, at the expense of the free ammonia. Such being the case, if the water had not been examined till the date of the second analysis, and if the nitrites had not been taken into account, this water would have been regarded as containing much less free ammonia than it did, and consequently that the previous sewage contamination was less than it really was; this point is therefore one of some analytical importance.

It is right for me to observe, in connexion with this latter fact, of the decrease of free ammonia in waters by keeping, that long after I had made that observation I met with, in the *Chemical News* for March 2nd, 1877, a letter written by Professor Pattison Muir of Owen's College, in which he calls the attention of chemists to some observations his brother had just made in the laboratory of the University at Sydney, in which he had noticed that the amount of free

and of albuminoid ammonia, as determined by Wanklyn's process, varied very considerably with the time the sample of water had been kept; but neither of those gentlemen has offered (in the letter referred to) any explanation of the fact, further than that Professor P. Muir throws out the suggestion, in the case of the increase by keeping of the albuminoid ammonia, that possibly it might have been owing to the germs which have escaped decomposition by the permanganate, undergoing a gradual decomposition in the water, and that ammonia is one of the products of this process. Be this as it may, I have satisfied myself that the loss of free ammonia is often due to the formation of nitrites or nitrates, which are very rapidly formed under different circumstances. And as regards albuminoid ammonia, the very slight increase which I observed in my experiment was, I thought, very easily accounted for by my having in the second determination carried on the process of distillation somewhat further than in the first trial, and in this way the amount might be very naturally increased.

Finally, my observations that nitrification is greatly promoted by warmth might, I conceive, admit of some practical application in the manufacture of the nitrate of potash in the artificial nitre beds, especially in those of cold countries; and I am not aware that heat has hitherto been anywhere artificially applied to hasten or promote that important manufacture.

XLI.—On Recent Researches respecting the Minimum Visible in the Microscope. By C. E. Burton.

[Read, May 26, 1879.]

Investigations for the determination of the magnitude referred to in the title of this paper have been recently made by Dr. Royston Pigott, and by Professor Abbè of Jena. Dr. Pigott has accumulated a number of data relating to the separability of details in the images of distant objects formed by any combination of lenses which is both aplanatic and achromatic for the conjugate focal distances employed, and also of short focus, when those images are viewed by a similarly corrected compound microscope, the optic axes of both systems being carefully adjusted to coincidence.

It is plain that if we assume that the light proceeding from the distant object to the focus of the image forming combination, which combination we will designate as A, pursues its course in strict accordance with the law of refraction, and with it alone, that we can very readily determine the linear magnitude of any detail in the image found by A, from the magnitude of the corresponding detail in the object used (meshes of gauze, window bars, &c.), the rate of object to image being equal to the ratio of the corresponding conjugate focal distances respectively. Dr. Pigott has published measurements which, upon the assumption just stated, would prove that linear magnitudes of less than $\frac{1}{400,000}$th of an inch could be distinctly discerned, and yet further, that lines could be separately distinguished when their reduced interval was approximately equal to $\frac{1}{1,000,000}$th of an inch.

I have repeated Dr. Pigott's experiments with some slight modifications, and have found that with two opposed objectives the equivalent foci of which were respectively $\frac{1}{8}$th and $\frac{1}{4}$th of an inch, that the image of a fine line at a considerable distance was still visible when reduced to a magnitude equal, on the above supposition of a strictly geometrical reduction, to over a hundred and forty thousandth of an inch. Using a $\frac{1}{16}$th by Ross, and $\frac{1}{12}$th by Hartnack, as the image forming and examining objectives, the fine line used as object was visible as a *geometrical* magnitude = a two hundred and eighty thousandth of an inch, and appeared sensibly as distinct as when viewed under the same visual angle by the naked eye.

The deductions just made as to the linear magnitude of the images of the distant fine line are, however, shown to be untenable when we consider that we have no means, as far as is known at present, of ascertaining the form and dimensions of the details of an image produced in the manner above described, other than the optical examination of it with the aid of a system of lenses which would produce a precisely similar effect on the rays from the object if placed in a similar position to that occupied by the image forming system A. Let the examining system be designated B. Then the rays which have been converged by A to any area in the common focal plane of the two objectives will diverge again symmetrically from that area to B, and

supposing both combinations to be perfectly corrected, would form an image of the object precisely similar to it in the rear of *B*.

The effect of any interference or of diffraction in the convergent cone from *A* will be undone in the divergent cone whose base is the front lens surface of *B*.

Therefore, whatever be the actual distribution of light and shade in the common focal plane of *A* and *B*, the resultant after passing *B* will be identical with the originant, *i. e.* the object of *A*. In other words, *B* merely restores the rays to the identical mutual relation which they possessed before entering *A*.

The existence of any aberration in either or in both of the objectives or combinations of lenses used, *A* or *B*, disturbs the relation of symmetry between the convergent and divergent luminous cones, and consequently renders the restoration of their components to their primary condition more or less incomplete. The final image thus becomes indistinct to a corresponding extent, so much so indeed that the method of Dr. Pigott approves itself as an extremely sensitive detector of aberrations outstanding in the opposed systems.

But it is evident that no information as to the separability of material lines as distinguished from focal images can be obtained by the method just described. In the case of material objects, the light which renders them visible has undergone very different treatment from that adverted to above. Every system of material points, the intervals of which are comparable in dimensions to the length of a wave of light, acts as a more or less regular diffraction grating when a pencil of rays is transmitted through it, and the pencil is redistributed in the process of transmission into a direct pencil, and a varying number of diffracted pencils dependent upon the number of regular diffracting systems, of which we may conceive the assemblage of material points to be composed, and divergent from the axis of the undiffracted pencil at angles which are determined by the degree of closeness of the several imaginary component gratings. The angles of divergence of diffracted pencils increase with the fineness of the details producing diffraction until they approach equality (for direct light) to a wave length of that light when the divergence becomes equal to 90°, or, in other words, diffraction ceases.

If the angular aperture of the observing objective be sufficiently wide, it will receive one or more of these diffracted pencils besides the direct pencil.

Professor Abbè's researches have resulted in showing that the representation of minute detail of *any* kind is dependent on the admission of rays from these spectra to the final image in the focus of the eye lens of the microscope, and that if these diffracted pencils be entirely excluded from the final image no detail at all will be shown, but merely the outline of the object viewed, *e. g.*, the edge and midrib of a diatom; its markings, so called, being invisible. Furthermore, Professor Abbè has proved that the fine details of an object will be shown more nearly as they exist, the greater the number of

the diffracted pencils admitted by the objective. If the admission of these spectra is interfered with either by the limitation of the angular aperture of the objective used from its original construction, or by intentional screening off of any of the diffracted pencils which would otherwise reach the final image of the object, the apparent detail will be modified in a corresponding manner. These facts may be very readily and simply demonstrated, when a microscope furnished with an objective of one quarter of an inch equivalent focus is directed upon a valve of *Pleurosigma Balticum*, for example. If the objective has an aperture of 90° or thereabouts, there will be seen, after focusing and removing the eye-piece in order to look down the tube of the instrument, a brilliant image of the mirror or source of illumination, and symmetrically disposed round this direct image, if it occupies the centre of the tube, four similar but much fainter images, coloured red at their outer and fringed with blue at their inner edges, if white light be used.

These faint images are the diffraction images of the source of light, each being composed of separate monochromatic, and individually accurate, representations of the luminous origin, which are distributed along a radius, commencing at the direct image, and arranged in order of increasing wave length. The composite image is therefore somewhat distorted, being elongated in a radial direction, and fringed with colour as above described, from the overlapping of the extreme images.

If the luminous source be a narrow slit allowing a sufficiently bright pencil to pass through a system of diffracting lines parallel to itself, some of the Fraunhofer lines may be seen, if solar light be employed, especially if the eye be assisted by a magnifying glass focused on the diffraction images.

If now we conceal any two opposite spectra by appropriate screens, and replace the eye-piece, we shall find that one of the systems of lines with which the object is apparently marked has disappeared, namely, that which is at right angles to the line joining the concealed spectra. If while we still hide the same two spectra we also block out the direct beam, the system of lines last mentioned will be replaced by another, the components of which are at half the distance of those just described, and twice as numerous.

This fact points the way to the explanation of the varying phenomena, which attributes the visible systems of lines seen in the image of such an object as we have chosen to the interference of the rays from the images of the source of light formed in the upper focal plane of the objective, where they meet within the eye-piece.

The process of production of these interference striæ is as follows; tracing the course of the light rays from the origin upwards, and assuming them to be parallel.

In the annexed diagram (1), let *a*, *b* be the incident beam falling

[1] *Vide* Note added in Press.

perpendicularly on two elements of a grating which are represented in transverse section by the thick short lines *c d*. The lines *f f'* re-

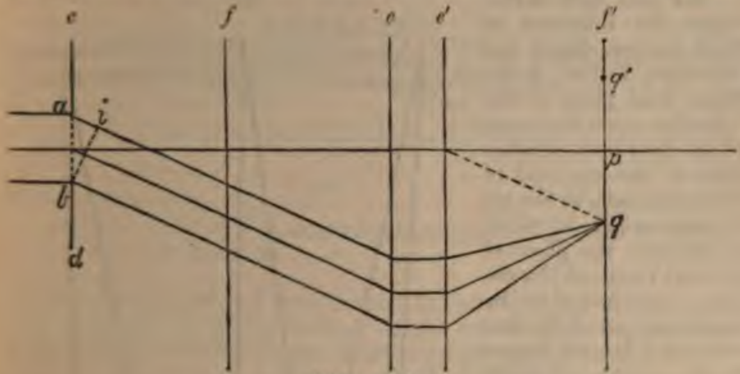

Diagram (1).

present the principal focal planes of the objective employed, and *e e'* the infinitely thin lenses which would produce refractions of the transmitted light equivalent to those actually caused by the objective itself; *p* is the point at which the light transmitted directly through the grating is brought to a focus. A bright line is consequently produced there if the source of light be a slit. But there will also be lateral diffracted rays, one of which is shown pursuing its course to a focal point in *q*. If *a i*, the difference in the length of the two sides of the beam, be equal to a whole wave length, the two sides will reach *q* in the same phase, and the result at *q* will be a bright line. If the difference in length of path be equal to only half a wave length, the result at *q* will be a dark line. In general, where the difference in length of path equals an even multiple of a half wave length, a bright line will be found in the plane of *f*; when, on the other hand, the difference equals an uneven multiple of the wave length, the result will be darkness.

Let α be the angle of inclination of the diffracted ray, λ its length of wave, and *a b* the breadth of the successive intervals of the grating, then we have for the first bright line $\sin \alpha = \lambda \div a\, b$; for the second bright line, $\sin \alpha = 2\lambda \div a\, b$, and so on. If light of a higher refrangibility, *i. e.*, of shorter wave length, be used, *q* and *q'* will be found nearer to *p* than before, because *a i* will have been diminished, and thus, if white light be employed, the image of the source formed at *q* and *q'* will be impure, and will appear fringed with colour, blue at the inner, and red at the outer edges.

If also the source of light be of sensible magnitude, the rays of each colour will form an infinite number of apposed images of the elements of its surface in and near *q* and *q'*, composing thereby perfect images which will overlay one another, and appear at each side

the plane f' as coloured edges, as pre

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the image
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eye lens of
roscope, by the aid
ram (2), in which
icates the place of
al image of the ob-
Let a and a' be the
t and one of the first
r of diffracted images
of the source of light. The rays emitted from a and a' will interfere at B, and if the distances $a\,B$ and $a'\,B$ differ by a whole wave length a bright line will be produced; if the difference be half a wave length darkness will result. From centre a strike two arcs, one through B, the other through a point distant from B by a wave length. From a' describe a third arc through the point within B. The crossing point P of the two arcs marks where the undulations starting from a and a' are found to differ by a whole undulation, and consequently where the first bright diffraction line is situated. The sides of the small triangle whose apex is in P, tho
circles, are so short that they may be considered straight
this triangle is similar to the triangle $a'\,aB$, we have

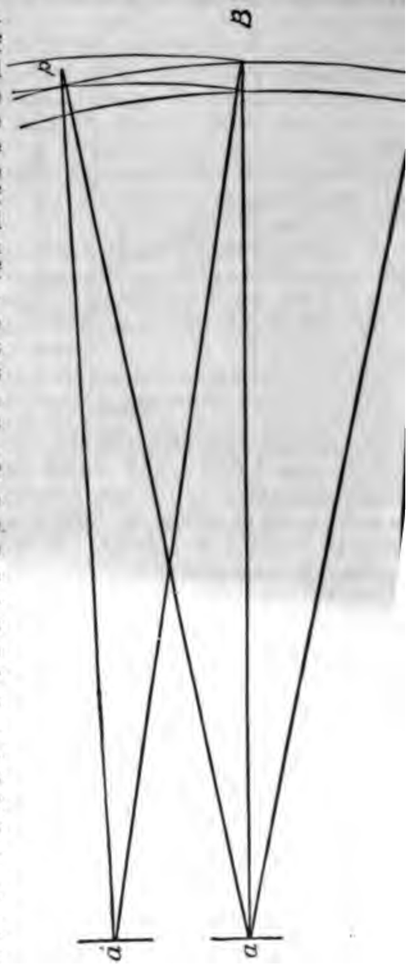


Diagram (2).

$$B\,P : \lambda = a\,B : a\,a';$$

or

$$B\,P = Ba.\lambda \div a\,a'.$$

Now Ba is = the conjugate focal length p' less the principal focal length f, or $p'-f$. Referring to diagram (1), we see that

$$a\,a' \text{ or } p\,q = \sin\alpha\,.\,f.$$

Since for the first diffracted pencil $\sin\alpha = \lambda \div d$, d being the distance of the striæ in the object, the above formula becomes

$$B\,P = \frac{(p'-f)\,.\,\lambda}{\frac{\lambda}{d}\,.\,f} = \frac{p'-f}{f}\,.\,d\,;$$

or, since

$$p'-f \div f = \text{the magnifying power } m;$$
$$\therefore B\,P = m\,.\,d,$$

i. e. the distance of the visible striæ in the real image of the object is equal in this case to the distance of the actual diffracting elements of the object multiplied by the magnifying power of the objective.

If the direct ray A is screened off, then the first of the equations just given becomes

$$B\,P = Ba\,.\,\lambda \div a'\,a'',$$

that is to say, since $a'\,a'' = 2\,a\,a'$, $B\,P$ is halved, or striæ will be seen, the intervals of which are half the intervals of the set seen in the first case. The reduction of the intervals of the visible striæ may be carried further by screening off all the spectra of the first, second, &c., orders.

It has been shown in treatises on Interference Phenomena that rows of dots, individually of any form whatsoever, will, if of sufficient minuteness, behave as if they were actual striæ, both species of intercepting systems producing identically the same phenomena. It matters not whether the dots in question consist of actual absorbing particles, of transparent elevations or depressions in a uniform membrane or shell, or of mere differences of refractive powers between adjoining portions of the same substance, the effect on the luminous undulations is the same in all cases of similar arrangement. All the markings seen on different species of diatomaceæ for instance might have been previously drawn by a person who had never seen a diatom in the microscope, had the grouping and distance *inter se* of the spectra seen at the upper focal plane of the objective been communicated to him. The diffracting obstructions originating the known appearances may belong to any of the classes just enumerated, but we do not know, and we never shall know *by mere microscopical inspection*, what the diffractive structures really are.

Lastly, it is easily seen that, as the visibility of minute detail depends on the diffraction spectra produced thereby, the limit of visibility is attained when diffraction ceases, or, in other words, when the angle α becomes equal to 90° for spectra of the first order. Referring to diagram (1), we see that this occurs when $a\,b = a\,i = \lambda$ of the light

employed, if homogeneous; always supposing that the aperture of the objective used equals 180°.

It is, furthermore, easy to show that if the incident light is as oblique as possible, the limit of visibility becomes $= \frac{\lambda}{2}$, or about 0·0002 millimeter, approximately = one one-hundred and twenty-five thousandths of an inch. Photography enables us to advance a little further into the unknown along this path, but the advance thus made is comparatively small.

Finally, I have to apologise for presenting to the Academy so rough a paraphrase of the work done in reference to this subject by Professor Abbè, and by MM. Nägeli, and Schwendener: my excuse is, that perhaps that work may thus be made known to some earlier than it otherwise would be.

NOTES ADDED IN THE PRESS.

I.—The diagrams (1) and (2) in the text are copied from Figures 125 and 128, at pages 222 and 226 of the 2nd German edition of Schwendener and Nägeli's work on the Theory and Use of the Microscope. Published by Engelman, Leipzig, 1877.

II.—It has been pointed out to me that the incapacity of the direct pencil for representing minute detail should be explained in few words, as the explanation has been omitted by the writers mentioned above. An object can give rise to a visible shadow only when the portions of the luminous wave which spread into the geometrical shadow destroy each other wholly or in part by interference, in consequence of the length of their paths differing by an uneven multiple of half an undulation. As the light which passes by the edges of a given microscopic object proceeds from the luminous source, it is in the same phase of undulation throughout at that passage, and consequently the secondary waves which bend into the geometrical shadow cannot interfere to produce a real shadow, unless the difference of the length of the lines imagined to be drawn from the edges of the object to any point of its geometric image be at least half an undulation of the light employed. If it is less than that quantity, the whole of the geometric shadow will be filled with light, and the object will be invisible. This applies to objects of any form or magnitude disposed in any manner whatsoever, and to ordinary, as well as to assisted vision.

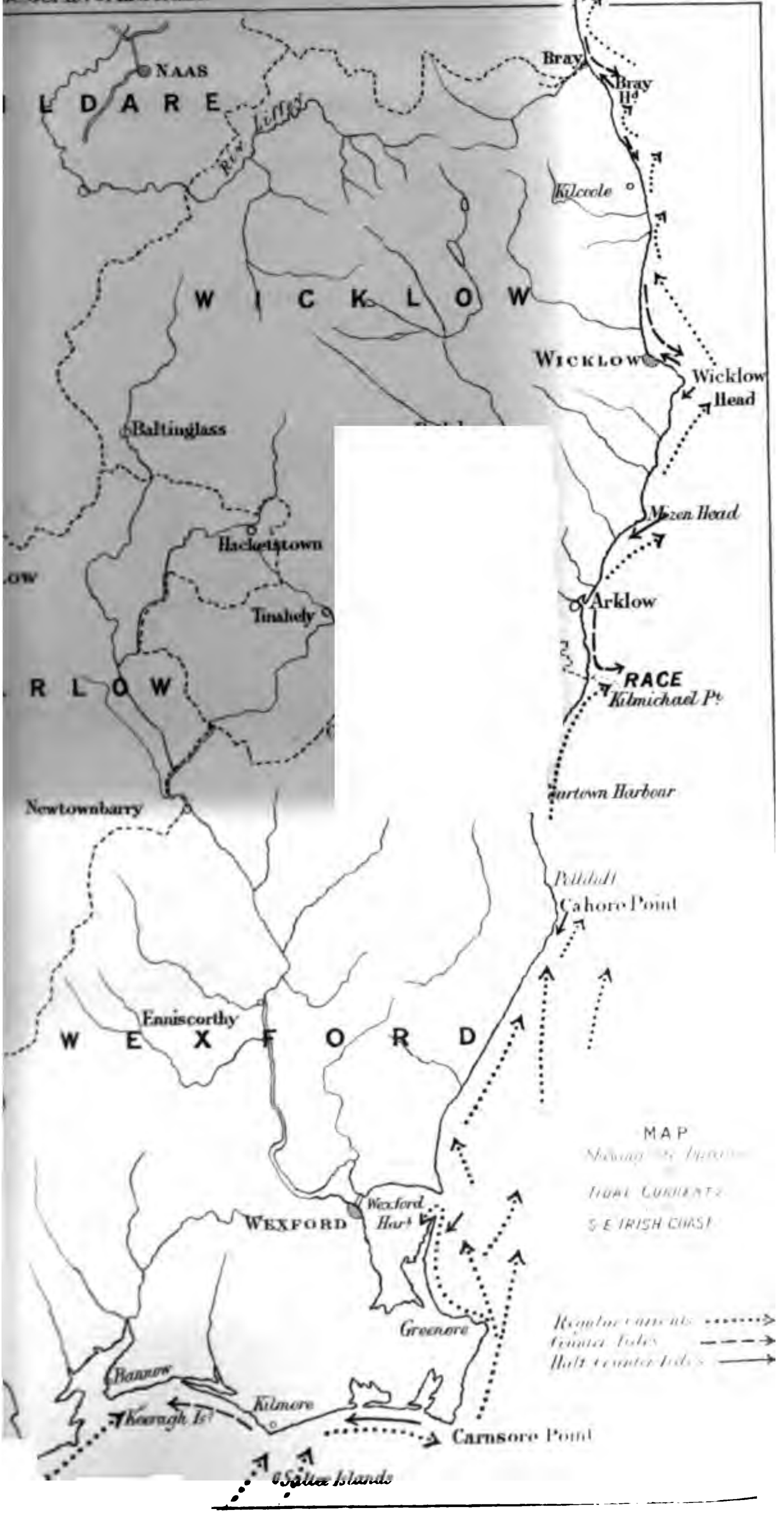

Dalkey
Bray
Bray Hd
NAAS
LDARE
River Liffey
Kilcoole
WICKLOW
WICKLOW
Wicklow Head
Baltinglass
Hacketstown
Tinahely
Mizen Head
Arklow
RACE
Kilmichael Pt
RLOW
Newtownbarry
Courtown Harbour
Cahore Point
Enniscorthy
WEXFORD
MAP
TIDAL CURRENTS
S. E. IRISH COAST
Wexford Harb
WEXFORD
Greenore
Bannow
Keeragh Is
Kilmore
Carnsore Point
Saltee Islands

Fig 1. Sketch Section of the Beach between Tacumshin and Camsore during a S.S.W. Storm when the Flow Tide was five hours old.

Fig 2. Sketch Section of Storm … t a Storm.

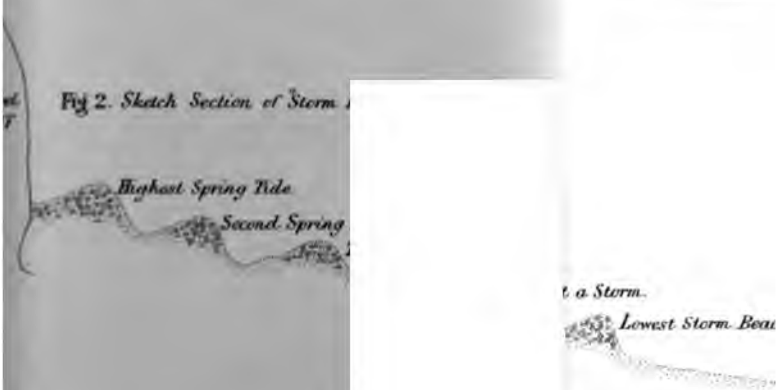


Fig. 3. Sketch Section of the Beach west of Tacumshin Lake. after the Gale of April 4th 1876.

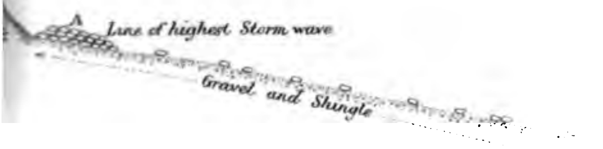
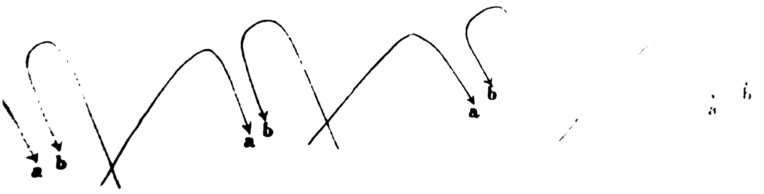
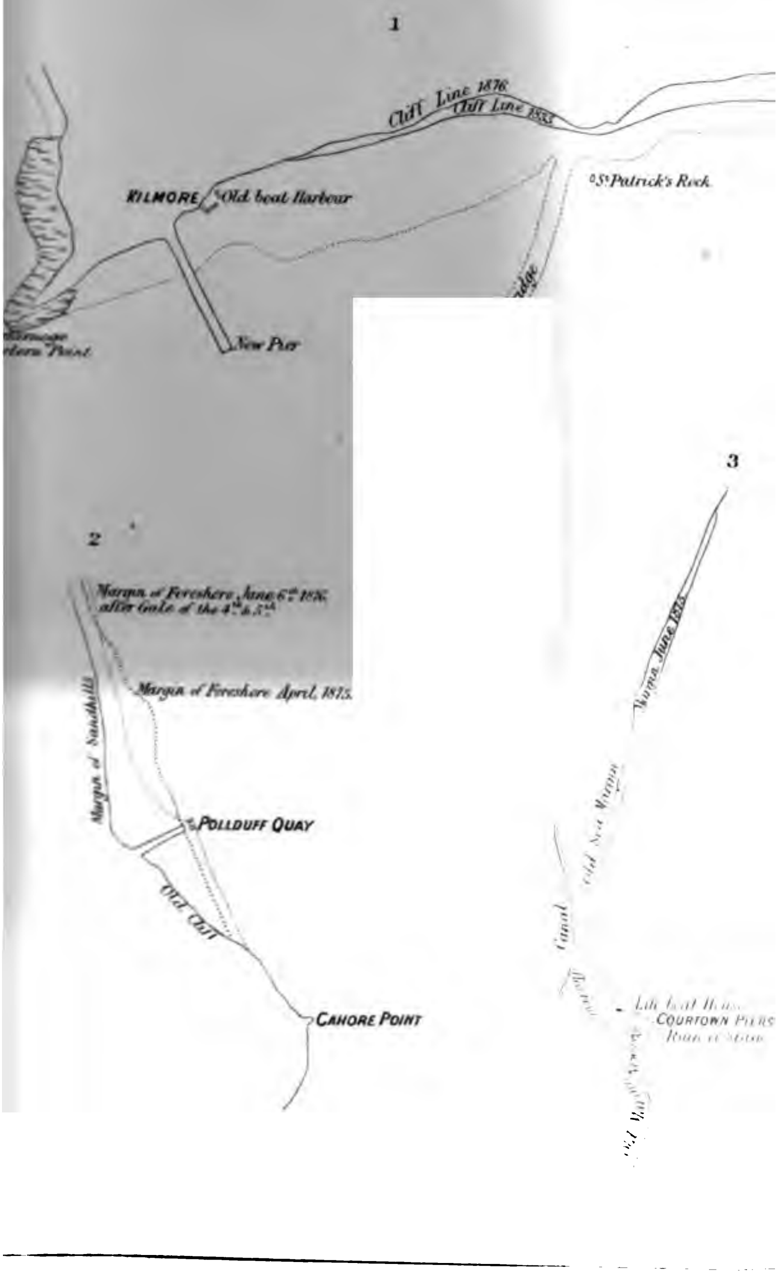


Fig. 4. Transversely ridged Beach the curved arrows represent the rise and return of the different waves




1
Cliff Line 1876
Cliff Line 1833
KILMORE
Old boat Harbour
St. Patrick's Rock
New Pier
2
Margin of Foreshore June 6th 1876 after Gale of the 4th & 5th
Margin of Foreshore April 1815
Margin of Sandhills
POLLDUFF QUAY
Old Cliff
CAHORE POINT
3
Margin June 1876
Old Sea Margin
Canal
COURTOWN PIERS

West View of the "Mill-stone," Contham Head, Port Moon, Co. Antrim.

East View of the "Mill-stone," Contham Head, Port Moon, Co. Antrim.

XLII.—NOTE ON THE METEORS CONNECTED WITH THE FIRST COMET OF 1870. By J. L. E. DREYER, M. A.

[Read, June 23, 1879.]

IN November, 1873, I published in the *Astronomische Nachrichten*, vol. lxxxii. No. 1963, a note on some minor radiant points of shooting stars which are in activity during the beginning of August, and which seemed to be connected with the first comet of 1870. For this comet I had the year before computed the orbit, based on a discussion of all the available observations,[1] and from this orbit I found the radiant point of the comet to be

$$\alpha = 27^\circ\ 51', \quad \delta = +\ 48^\circ\ 24',$$

while the comet in its descending node (which the earth passes on August 14) was only 0·014 distant from the ecliptic, the mean distance of the earth from the sun being unity.

This note has apparently not attracted the notice of the committee on luminous meteors of the British Association, as the radiant of the comet I. 1870, in the "Reports" for 1874, 1875, and 1878, is given as $\alpha = 43^\circ{\cdot}5$, $\delta = +\ 53^\circ$, which position, as well as the date (August 12), is unquestionably wrong.[2] The conclusions based on this erroneous radiant point are therefore, of course, also wrong. In my note in the *Astron. Nachr.* I had only mentioned the following three actually observed radiants of meteors as being in pretty good accordance with the computed radiant of comet I. 1870 :—

August	3	$\alpha = 35^\circ$	$\delta = +\ 44^\circ$	Zezioli,	No. 132
,,	11	24	58	,,	,, 141
,,	3–12	31	55	J. Schmidt,	,, 46 (A.N. 1756).

Since then, however, the following positions of radiant points have been published in the "Reports" of the British Association :—

Aug. 10	(1868)	$\alpha = 33^\circ$,	$\delta = +\ 59^\circ$	(Forbes, "Rep.," 1874, p. 334).
,, 9–12	(1872)	33	57	(Italian obs.—see *The Observatory*, vol. ii. p. 165).
,, 8–11		25	59	(Lorenzoni, "Rep.," 1876, p. 160).
,, 10	(1876)	33	56	("Report," 1876, p. 154).
,,	(1876)	31	59	(Denning, "Rep.," 1877, p. 176).

The cluster χ Persei ($33^\circ + 56^\circ$) is often mentioned as a radiant of meteors—*i. e.* by Mr. Clark of York ("Report" for 1877, p. 158), and by Mr. Denning, who finds a group of stationary meteors at $32^\circ + 57^\circ$.[3]

Whether the above radiants are all identical or not, we have here to do with a phenomenon entirely distinct from, though similar to, the great annual star-showers which bear the name of the Perseids, and

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[1] *Astronomische Nachrichten*, Vol. lxxx. No. 1910.

[2] In a separate copy of the Report of the committee on luminous meteors for 1878 (placed in my hands by Dr. Ball), Prof. Herschel has corrected the position to $25^\circ{\cdot}5 + 45^\circ$, which comes nearer to the true position.

[3] "Monthly Notices," R. A. S., xxxix. p. 407.

move in the same orbit as the great comet III. 1862. The orbit of the comet I. 1870, appeared at first very like that of the last-named comet; but my final determination of the orbit gave elements less like those of the Perseid comet. All the same, it is very interesting that the two comets show their meteors almost on the same days, and the aphelia being pretty near each other, the whole system of comets and meteors form one of those "comet families," of which the researches of M. Hoek have found so many instances.[4]

Subordinate radiants do not only appear in the case of the Perseids: there are a good many such groups of radiants known. There are two ways in which such neighbouring radiants may have originated: either a great accumulation of meteors moving in the track of a comet may have been disturbed by the earth at some distance from it—great enough to prevent the swarm from being scattered, and yet small enough to make it move in a new orbit;—or the attraction of the earth on the single meteors, which pass us closely, may make the orbit have a number of radiants instead of a single one. The curve, which a meteor will describe round the earth, is a hyperbola, the asymptotes of which are two lines in the directions in which the meteor approaches and leaves the sphere of attraction of the earth. When we pass through a swarm of meteors, the earth is therefore perfectly enveloped by such hyperbolas, along which the meteors will move in all directions, instead of going in parallel orbits, as they did before meeting the earth. Once, therefore, a certain meteor has passed close by the earth, it cannot, if the orbit is a closed curve, and we meet it a second time, appear to come from exactly the same point in the heavens—in other words, the radiant will be slightly different. According to Oppolzer, the time of revolution of the great comet of 1862 is 121 years. If, then, the Perseus-meteors are particles which gradually have been separated from the main body or nucleus of the comet by evaporation of the parts nearest to the sun, and by the subsequent condensation of these vapours into a number of small bodies, the main stream of these would be surrounded by a number of scattered bodies, moving in orbits more or less different from that of the main stream, and these straying meteors would, it appears, produce the phenomena of secondary radiants.

It does not, however, seem likely that the meteors, which radiate from a point near χ Persei, have originated in this way. As the radiant is so near that of the comet I. 1870, the elements of which are not a little different from those of the comet of 1862, it seems probable that the two meteor-showers are independent of one anotehr, each being composed of matter left behind by its mother-comet. But, besides the meteors from near χ Persei, there are many other Circum-Perseid meteor-showers, as amply shown by Mr. Denning (Brit. Ass. "Report," 1878, p. 344); and it appears likely that at least some of these have arisen from the perturbations caused by the earth, as described above.

[4] "Monthly Notices," R. A. S., xxv., xxvi.

XLIII.—CONTRIBUTIONS TO THE STUDY OF NERVE-ACTION IN CONNEXION WITH THE SENSE OF TASTE. I.—FUNCTION OF THE TRIGEMINUS. By GEORGE SIGERSON, M. D., CH. M., F. L. S.

[Read, June 23, 1879.]

IT is a remarkable fact that, whilst the study of some of the special senses, such as those of sight and hearing, has made great progress, that of the sense of taste remains still in a very imperfect condition. The difficulties in the way of its elucidation are evidently considerable, for we find that contradictory results have been arrived at by various observers of repute. Unquestionably much advance has been made since the physiological doctrine, as stated by Boerhaave and Duverney, was in unison with popular opinion, in regarding the tongue as the only seat of taste. De Jussieu, disturbing that concordance, placed physiology on the true path of research when he pointed out that taste was still preserved after the excision of the tongue, and that it was present in those from whom the tongue was congenitally absent. These pathological facts proved, not of course that the tongue was devoid of this special sense, but that other parts within the buccal cavity possessed the power of distinguishing sapid impressions. When, however, it became a question of differentiating and localising the taste-power, the difficulties increased with the accumulation of facts. Hence, even at the present day, most points of importance in connexion with this subject should be looked upon as still in dispute, if we are to accept the statement embodied in the most recent edition of a standard physiological work. Professor Hermann[1] of Zürich, having mentioned that it is difficult to separate the taste-sense from simultaneously evoked odorous and tactual sensations, and to strictly localise the test-fluid, makes the following statement:—"The special seat of the gustatory sensibility has therefore been very differently stated. Undoubtedly, the root of the tongue plays an important part, but it is doubtful whether it alone (Bidder, Wagner), or also the tip and the borders of the tongue (Schirmer, Klaatsch, Stich, and Camerer), the soft palate (J. Müller, Drielsma), or at least a part of it (Schirmer, Klaatsch, and Stich), or even the hard palate (Drielsma), are seats of gustatory sensation."

The method of research by means of physiological experimentation on animals affords us only a limited assistance; for, as animals cannot give us an intelligible expression of their sensations in this matter, the results obtained are often unsatisfactory, and have sometimes proved misleading. Undoubtedly many valuable facts have thus been acquired, but it seems almost impossible, by this method, to distin-

[1] Hermann, *Elements of Human Physiology*, p. 458, London, 1878.

y, for instance, between degrees of impairment in the ns of different sapid substances.

the most skilful vivisector. It can stimulate to excess , and enable us to observe the result; or, by paralysing it, nder the nerve wholly inactive, and thus withdraw a fac- us to determine its function by observing the consequences .e. In presence of so complex a problem as that before us, as that the sources of possible error of observation are many. ..less where the attention of the observer has been specially to determining the topography of taste, it is impossible to he recorded results as satisfactory. Thus, frequently, if not uy, in ordinary practice the patient is allowed to withdraw the before signifying whether or not he perceives a taste. In such we can come to no conclusion against a localised abolition of nse, inasmuch as the withdrawal of the tongue, and its subse- ent motion within the buccal cavity, will bring the sapid substance in contact with regions where the taste sensation is still preserved. Where precautions have not been taken, with special reference to h dangers, the statement of a positive result cannot be taken as ly excluding the presence of a localised paralysis of taste—say, for instance, in the anterior border of the tongue. Or, if the substance be aromatic, its presence may be recognised (ex hypothesi) by the olfactory sense alone, and yet the patient's declaration that he tastes it may be recorded as an instance of the conservation of the gustatory sense. Non-attention to these sources of error has been the cause of the reception of many of the contradictory results which help to obscure the study of this subject.

Hence, a simple enumeration of recorded results does not, of necessity, increase the weight of evidence, with reference to disputed points, unless it be manifest that the observers who recorded them had their attention particularly directed to the elements of the problem. Such examples have an exceptional interest, and are of great utility, when employed to control and verify the results of a physiological experimentation on animals.

With the desire of adding something to the exact study of this important question, I venture to submit the following observations which have a direct bearing upon the action of some nerves, and indirectly serve to elucidate the function of others.

I.

1. *Function of Palatine Nerves.*—The facts which I have observed relate to the soft palate. The innervation of this region is somewhat complex. The anatomical investigations of M. Debrou, and the physiological experiments of Dr. Volkmann, go to prove that it receives branches from the glosso-pharyngeus, which supplies the levatores palati and the azygos uvulæ. This is a mixed nerve, and its galvanization demonstrated, by inducing contraction of these muscles, that

it furnished them with motor twigs. It is presumed that sentient fibres are sent to the mucous membrane. The circumflexus or tensores palati receive motor twigs from the inferior branch of the trigeminus, contracting when it is stimulated. Again, stimulation of the pneumogastric, a mixed nerve, induces contraction in some of the palatine muscles (Bischoff and Reid). From Meckel's ganglion, the spheno-palatine (which receives its sensory supply from the superior maxillary, or second division of the trigeminus), some branches proceed to supply the hard and soft palate, tonsils, and uvula. Of these the anterior palatine branches are described as sensory (Robin), whilst the posterior are mentioned as destined for the levatores palati and azygos uvulæ. A pterygo-palatine branch supplies the mucous membrane of the Eustachian tube, and that of the adjacent nasal and pharyngeal region. The otic ganglion (Arnold's) receiving a root from the inferior maxillary (said to be its motor supply), receives also in its long slender root (Arnold's minor superficial petrosal nerve) a supply from Jacobson's nerve which brings the glosso-pharyngeus into communication with the trigeminus. It is asserted, however, that the branches given off from this ganglion (which they merely pass through) come from the motor portion of the trigeminus; they supply, according to Robin, the levator palati, the internal pterygoid, and tensor tympani. It does not appear to me to be demonstrated that only motor branches are given off to the palatine region. Professor Hermann, having stated that the otic ganglion gives off two branches, one to the tensor tympani, and another to the tensor palati, remarks: "The physiological importance of this little centre is, however, in all probability, much greater than one would conclude from the fact of its merely giving off these two small muscular branches, as it is probably through it that the fibres of the facial, contained in the small superficial petrosal nerve, make their way to the auriculo-temporal nerve (5th), and thence to the parotid gland, for which they are most probably secretory. Further, it is probable that, through the otic ganglion, fibres of the glosso-pharyngeal, derived from its tympanic branch, make their way to the facial nerve."

Incidentally, the importance of this ganglion, as a connecting junction, will be illustrated by the facts of the cases which follow. In the first case, a patient affected by a pontine lesion had complete facialis paralysis on the left side of the face. On that side, however, the sense of hearing remained perfect, and the sense of taste was left intact which would not be the case if, as some have asserted, the facial nerve shared in it. On the right side there was paralysis of the inferior maxillary branch of the trigeminus. There was, consequently, absence of sensation in the external ear and integuments of the lower jaw. Thus, owing to the anæsthesia and analgesia, the patient did not feel the razor whilst shaving, and sometimes cut his cheek without his attention being aroused by pain. There was a certain degree of diminution of the senses of taste and touch observed on the right anterior portion of the tongue, the cause of which I shall discuss

further on. Besides the unpleasant sensation of "dead numbness," as the patient called it, which affected the external ear, down through the meatus, there was marked loss of auditory power. In order that he should hear the tick of a watch it was necessary that it should be applied close to the ear. This defect came on simultaneously with the anæsthesia of the inferior maxillary nerve, and passed away as the latter began to improve. The progress was different from that I obtained where the auditory nerve was itself affected. It seems impossible, therefore, not to connect these two facts in relation as cause and effect; the paralysis of the inferior division of the trigeminal nerve inducing a degree of deafness corroborates the opinion of M. Robin, who states that the motor branch, derived from it, simply passes through the otic ganglion to supply the internal muscle of the malleus.

This connexion being made clear, I pass to the second case. In this instance, a young patient came to me, complaining in almost the same terms, of deafness and unpleasant numbness in the right ear. It was necessary that the watch should be quite close to his ear to enable him to hear it ticking. Sensation was, however, intact over the face. On examining the throat I at once perceived a relaxation of the palatine muscles on the same side; and further tests showed that I had before me a strictly localised paralysis, affecting the nerve-branches which proceeded from the otic ganglion to the tympanum, on the one hand, and to the palate on the other. The spheno-palatine nerves could be excluded, for the region supplied by their anterior branches (described as sensory) was not affected by the paralysis, and there seems no probability (nor does it, indeed, matter to the question) that the posterior muscular branches were affected.

This localised paralysis afforded an opportunity of studying what changes, if any, resulted in the palatine region supplied by the nerves affected. As one-half only of the soft palate was involved, an immediate comparison could be made, in the same individual, between the results of tests applied on both sides.

It was obvious, in the first place, that motor filaments had been supplied, and were paralysed: but is the statement accurate that the nerve-supply is purely motor? That, I may say, seems at the outset a somewhat gratuitous assertion, considering the character of the otic ganglion. The pathological facts observed in the palatine region in consequence of this localised paralysis were the following:—

1°. Motor paralysis of certain muscles supervened;

2°. There was loss of heat-sense—the patient not being able to detect the heat of a warm gargle on the affected side;

3°. There was marked loss of the sense of touch;

4°. Sense of pain was very greatly diminished;

5°. Finally, as regards the sense of taste, the existence of which in the soft palate some have contested, I found that it unquestionably was present on the healthy side, and that it was almost, if not quite, abolished in the paralysed half of the palate. When test-fluids,

which were not perceived on this side, were drawn across the mesial line, there was an immediate contortion of the face.

It follows, from the foregoing facts, that the nerve-supply proceeding from the otic ganglion is sensory as well as motor; sentient filaments of the fifth, and possibly loan-fibres of the glosso-pharyngeus accompany the motor nerves to the palatine region.

II.

Function of the Lingual Nerve—The function of the lingual branch of the trigeminus has been a subject of dispute, especially since Pannizza of Pavia denied, in 1834, its connexion with the sense of taste, which he considered to be under the exclusive sovereignty of the glosso-pharyngeus. According to his view, the lingual was solely concerned with the tactual sensibility of the tongue. Magendie, five years later, propounded a doctrine which was the exact contradictory of this opinion; for he maintained that the lingual is, and is exclusively, a nerve of taste. Against this it is asserted that he must, in operating, have mistaken a pharyngeal branch of the pneumogastric for the glosso-pharyngeus, and that he, consequently, drew his conclusions from faulty premisses. More trustworthy testimony against the contention of Pannizza is to be found in the experiments of J. Müller, and especially in the later experiments of my friend Professor Schiff, of Geneva. The result of their researches goes to prove that taste is not quite abolished when the glosso-pharyngeus is divided, though it is greatly diminished. It is true that the animals operated on (dogs and cats) did not refuse to lap milk with which colocynth had been mingled; but, on the other hand, when pure milk was placed alongside of milk so prepared with a bitter, they displayed a distinct preference for the former. This would appear to demonstrate that the trigeminal nerve-supply is capable of conveying gustatory sensations of some kind. Hirschfeld and Valentin, however, have supported the opinions of Pannizza on anatomical grounds. Various experiments have shown that, of the anterior part of the tongue, the dorsum is scarcely, if at all, susceptible of receiving taste-impressions, whilst the edges and point are sensitive to them. Hirschfeld and Valentin maintain that the difference is due to the anatomical fact discovered by them, namely, that an external branch of the glosso-pharyngeus proceeds along each margin of the tongue to the tip. Hence, they hold that Pannizza's view still remains the correct one, asserting that the glosso-pharyngeus is the sole nerve of taste. Their adversaries, however, declare, on the other hand, that as the lingual nerve sends a recurrent branch to the base of the tongue, the sensibility to sapid impressions existing there, which has been referred altogether to the distribution of the glosso-pharyngeus, must be claimed for the lingual nerve.

I may here point out that, if either of these doctrines be accepted, and it be granted that the sense of taste is the exclusive appanage

of one or other of the nerves named, a new and considerable difficulty would arise. Several physiologists, amongst them being Vernière, Admyrauld, Longet, Neumann, and Rosenthal, have made experiments with a view to localise the different kinds of sapid impressions. The general result, so far as the tongue itself is concerned, seems to be that the base is sensitive to bitter impressions, and the edges and point to saline, sweet, and acid savours especially.[2] Now, if the same nerve supply both regions, it is obvious that this remarkable difference stands in need of an explanation. Of course, such a difficulty as this could not exist if we accept the opinion of HH. Bidder and Wagner that the root of the tongue alone, and not the edge and point also, is sensitive to taste-impressions. But whilst this view is in contradiction to that of most experimenters, and indeed to general experience, it would only displace one difficulty in order to substitute another; for if it be hard to conceive that the same nerve should not receive a bitter savour in the anterior part of the tongue whilst it does perceive it at the base, it is still harder to understand how it should receive all taste-impressions at the base, and reject them all in front.

Such being the state of the question, in which almost everything is yet under litigation, I venture to offer for consideration the following facts, which, I hope, will help to elucidate the action of the lingual nerve. Pathology, in this instance as in others, may lend its assistance to experimental physiology, and, by removing a factor, enable us to understand, by the consequences of its absence, the function which it fulfilled when in activity.

The pathological facts were observed in a case which, owing to the peculiar nature of the lesion, was exceptionally well adapted to present them with clearness, and to permit of comparison and verification. The lesion occupying a position in the bulbar region of the pons varolii, complete paralysis of the facialis nerve had supervened on the left side of the face, whilst on the other this nerve was unharmed. Here, however, on the right side, the third or inferior maxillary branch of the trigeminus was paralysed, with result of depriving the cutaneous surface of the corresponding region of its normal sensibility to touch and pain.

When the condition of things in the interior of the buccal cavity is considered, it will be remarked that a rare opportunity was presented of ascertaining the functions of the nerve-supply derived from the facialis, and the trigeminus, inasmuch as the former was eliminated as a factor from the left, and the latter from the right side of

[2] Pathology supplies facts which tend to accentuate this difference. Thus, in the case of a patient affected with aphonia, sweet mixtures were rejected and "could not be taken," whilst bitters were readily accepted. This would appear to indicate that there are special fibrils for the conveyance of different sapid impressions, and that they may become subject to hyperæsthesia. Numerous instances could be given in which intolerance of certain flavours is found to exist.

the tongue. Such an opportunity was desirable, because of certain inferences drawn from disturbances of taste observed occasionally in cases of hemi-facial paralysis, which would attribute gustatory power to the facialis. It was of considerable interest, likewise, in connexion with the much-debated question of the physiological function of the chorda tympani; which I reserve for discussion to another occasion.

Now, the result of the paralysis of the inferior maxillary nerve, and consequently of its lingual branch, was that the right anterior two-thirds of the tongue were distinctly less sensitive to touch and taste than the left. Yet as there was complete facialis paralysis on the left side, and as the lesion was not only intra-cranial but intra-pontine, there is every probability that whatever fibres the facialis gives to the chorda tympani were paralysed. It appears to follow from this, that whatever connexion the latter nerve may have with the sense of taste is not attributable to any filaments it may receive from the facialis. This goes to support the conclusion of Professor Schiff, who holds that the chorda tympani represents loan-fibres which had been previously borrowed by the facialis from the trigeminus.

Another question is suggested here, namely, the relationships of the lingual and chorda tympani, respectively, to the senses of touch, pain, and taste. Lussana and Inzani, in 1869, report a case where, after section of the chorda tympani, in the middle ear, the anterior two-thirds of the tongue lost their sensibility to sapid impressions, whilst still sensitive to touch and pain. A complementary fact is found in the result of an experiment by Professor Schiff, who, on dividing the lingual nerve above its junction with the chorda tympani, observed that the anterior two-thirds of the corresponding side of the tongue became insensible to touch and pain, whilst some sensibility to taste-impressions were preserved.

In the case to which I have referred, there was impairment alike of sensibility to touch and to taste. An incident occurred which served to explain the reason of this double impairment, and to furnish a revelation of physiological mechanism of great interest. Owing to a certain want of care on his part, the patient got an attack of tonsillitis; and as a consequence his tongue became "loaded," covered with white fur. In due time, the disorder gave way to treatment, and then a phenomenon was remarked which I will state in the words of a note made at the period :—

"Nov. 24. Tongue completely loaded, white all over.

"Nov. 25. This morning, tongue presented nearly the same appearance. During the course of the day, the left half became clean and red, whilst the right (trigeminal-paralysed) half remained loaded. The right half was quite loaded from tip to back, when I saw him in the evening, whilst the left half was quite clean.

"Nov. 26. Tongue has cleaned still more, but the cleaning has gone on, from left to right,—about a quarter of an inch has now

cleaned off to right of mesial line. This may be due to some intermingling of twigs of left trigeminus with twigs of right. Both being present, there would not be so much recuperative power there as on the left side, where only (the healthy) one present; yet more than on the right side, where the only one present was paralysed."

The whiteness of the right half, comparing so strangely with the redness of the left, continued for two or three days longer before the tongue became completely clean.

From these facts, it is imperative to conclude that the cleaning of the tongue depends directly on the activity of the lingual branch of the trigeminus. Where this activity was diminished, the region supplied by the nerve remained loaded for a considerable time beyond the period of the removal of the fur from the adjoining region, in which the action of the nerve continued. This is a distinct revelation of the trophic influence possessed by this trigeminal branch over the mucous membrane, and papillæ, to which its filaments are distributed. We may infer from what precedes, that the pathological phenomenon of furred tongue is due, at least in a great measure, to temporary paresis of the lingual nerve. The fact that, in some cases, the fungiform papillæ stand out as red points over the white surface does not contradict this opinion, but rather yields it support, inasmuch as their nerve supply being greater than that given to the filiform papillæ, they would thus give way later. Conversely, it may be deduced from the preceding facts, that where the tongue is abnormally red there is unusual excitation of the nerve in question.

Obviously, impairment of taste and touch is a necessary result of the arrest of normal trophic change over the surface of the tongue. When desquamation does not take place, or takes place but slowly, the epithelial scales which remain interpose an obstacle to the due conveyance of impressions; and, whilst remaining, they may undergo morbid change. The loaded tongue cannot perceive sapid impressions well, and we have reason to presume a certain amount, or as it were a film, of effete matter unremoved on the surface of the tongue, whenever there is paresis of the lingual nerve. Hence, we should be on our guard against considering (as some have done) that the impairment of taste which follows paralysis of this nerve is an absolute demonstration of its gustatory power.

An objection to my statement concerning nerve-influence in connexion with the production of fur may, perhaps, be supposed to exist in the opinion that the fur which appears on the tongue is formed by external parasites. Some words on this subject are consequently necessary. Whilst regarding this morbid phenomenon as due mainly to the presence of altered or moulting epithelial cells, it is not, of course, denied that minute plants may be found within the buccal cavity. This has long been known; and it may be added that they appear not only on the tongue, but on the gums, and elsewhere, and have not been regarded as essential to the formation of the fur, of which Rindfleisch, the distinguished histologist, remarks:—"What is

called 'fur on the tongue' is merely the result of a considerable desquamation of the epithelial pavement cells which characterise the mucous membrane of that region."

A different view, however, has been proposed by Mr. Bultin, F. R. C. S., in a paper recently read before the Royal Society of London,[3]—the object of his essay being, as he states it, "to show that schizomycetes form the essential constituent of the fur, and to show as far as possible some of the laws which govern the formation of the fur." His theory may be thus summarised: "The tongue," he says, "is kept clean by free movement, and by being rubbed against the interior of the mouth, gums, and teeth; but fur almost always exists on the surface both in health and in disease. The fur is generally thickest in the morning before food is taken, and during illness, when the necessary cleansing is not properly performed." Observed under a microscope the scrapings of a furred tongue show: "1°. debris of food, and bubbles of mucus, and saliva; 2°. epithelium; 3°. masses which appear at first to consist of granular matter, but which are the glœa of certain forms of schizomycetes." These glœa, he observes, are so closely attached to the hair-like processes that these come away with them, and where they are found "the filiform papillæ, instead of exhibiting fine, clear, tapering processes, terminate in processes which are uneven, tuberculated or beaded, and blunted at the ends." This alteration in appearance he considers to be "owing to the presence of these bodies."

With reference to these statements, it may be replied: 1°. that it has not been demonstrated that the deformation of the epithelial processes is not due to pathological alteration, rather than to parasitic growth. Such an alteration would be represented by what my distinguished master, Professor Ranvier, has termed "la tuméfaction trouble des cellules." This turbid cell-tumefaction takes place under like conditions. Whenever a slight irritation exists, or an abnormal variation of the nutritive fluid occurs in the epithelial tissues, "the epithelial cells swell and become filled with an albuminous fluid, containing fine granulations." This, in my opinion, would be the immediate cause of the alterations of the epithelial cells in case of furred tongue. On a mucous surface, so altered, it is quite conceivable that parasitic growth should soon form, because the "vital" resistant power of the tissue must be considerably lessened. It may be added, that if the formation of fur were due, essentially, to the proliferation of parasites, it would be very difficult to understand its occasionally rapid disappearance, either without remedies, or on the exhibition of medicines which are not known to be parasiticidal, and are not applied to the tongue. It would be impossible to account for the cleaning of one half the tongue, whilst the other half remained loaded, in the case quoted, if we take the view of Mr. Bultin as correct.

[3] "On the Nature of Fur on the Tongue," by Henry Trentham Bultin, F.R.C.S.—*Proceedings of the Royal Society*, No. 195, 1879.

In the second place, I do not believe we can accept the purely mechanical view of the cleaning of the tongue which Mr. Bultin has embodied in these words: "The tongue is kept clean by free movement, and by being rubbed against the interior of the mouth, gums, and teeth . . . the fur is generally thickest in the morning, and during illness, when the necessary cleansing is not properly performed." It is scarcely necessary to remark that the state of the tongue varies much in disease, and that even in the course of one affection, *e. g.*, typhoid fever, it may alter considerably in appearance. Again, in some disorders, when there is no reason to suppose the tongue unduly active, it becomes, so to speak, abnormally clean and red.

If the proposition laid down were correct, then we should expect to see the tongue furred in proportion to its inactivity. This, however, is not so. In the case of Mr. L——, that side of the tongue from which the fur first cleaned off was precisely the side which was paralysed as regards movement, and owing to the facialis paralysis, the cheek had fallen away, flaccid, and did not press the food into the cavity of the mouth, and towards the tongue, as was normally done on the right side, where the fur, in spite of all friction, remained persistently. Again, in cases where the tongue is more or less completely deprived of the power of motion, by paralysis or atrophy, it should, if this theory held good, be thickly coated with fur. But the fact is that the active tongue of (say) a scarlatina patient will be heavily loaded, whilst the motionless tongue of a paralytic may be free, or at least present no abnormal appearance. In labio-glosso-laryngeal paralysis the tongue remains, at a certain stage, motionless, and yet, as I can testify, it is not necessarily loaded. In this disease, first described by my regretted master, Dr. Duchenne (de Boulogne) the debility of the tongue is accompanied by an accumulation of viscous saliva, as he observes, but he distinctly points out that, "nevertheless, neither redness nor any alteration whatever of the buccal or pharyngeal mucous membrane is to be remarked."[4] Professor Charcot, in his great work on Diseases of the Nervous System, describing a case of glosso-laryngeal paralysis,[5] mentions that the patient could no longer make herself understood, the only sound she could produce being a nasal grunt: she could, indeed, protrude her tongue, and move it from side to side, but she could neither turn up the tip, nor apply its dorsal surface to the palate,—thus she could not rub it. Nevertheless, the tongue appeared quite normal. It is useless to multiply instances: enough has been said to prove that the production or removal of fur does not depend, to any marked extent, on the less or greater power of motion possessed by the tongue.

I have already indicated that, when the nerve-action is enfeebled or paralysed, the vitality (so to speak) of the corresponding region is lowered, and the tissue then becomes less able to resist the activity of

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[4] Duchenne de Boulogne, *De l'Electrisation localisée*, p. 568: Paris, 1872.

[5] Charcot, *Leçons sur les Maladies du Système Nerveux*, p. 426: Paris, 1877.

external agents, amongst which we may enumerate parasites. This statement may be illustrated by the facts of another case, which was noted down in 1864, and was made the subject of a Paper by the late Professor Gubler. In this case, the symptoms of which, unfortunately, were not given with much minuteness, we find the existence of anæsthesia of the trigeminus mentioned, as supervening upon another disorder. Sensibility, consequently, was impaired over the left side of the face. The patient having complained of dryness of the mouth, and disagreeable sensations there, attention was directed to the state of the buccal cavity. On examination it was ascertained that the gums and inner side of the cheek on the left side were distinctly drier than the corresponding parts on the right. In addition, a very striking phenomenon was observed. On the left, that is, the anæsthetic side, white granular patches were found disseminated over the posterior gums, the genial mucous membrane, and the angle of the upper and lower maxillæ. Nothing of the kind was to be discovered on the right side. On microscopic examination of scrapings of the white patches, epithelial cells, spores, and numerous long filaments of *Oidium albicans* were found.[6]

This case supplies an interesting and instructive corroboration of certain conclusions drawn from the facts which came under my personal observation, and gives us some additional data for judging the mechanical cleansing theory. Here were two regions perfectly identical as regards their motor conditions, as well as with respect to whatever friction they might experience. From one region, however, the influence of the trigeminus was more or less completely withdrawn, owing to its paralysis, and, in this region, parasitical growths were found to develop on the surface membrane, whilst no such phenomena were discoverable in the region where trigeminal action remained intact.

From what precedes, it is necessary to conclude:—

1°. That the action of the trigeminus influences, in a marked manner, the nutrition of the epithelial cells of the tongue and other parts to which its filaments are distributed.

2°. That diminution of its action is followed by diminution of the desquamation process.

3°. That, owing to this arrest of elimination of effete cells, the senses of Touch and Taste become impaired.

4°. Diminished action of the trigeminus results in diminished power of resistance, on the part of the corresponding surface membrane, to the action of pathological alteration in its anatomical elements and to the invasion of external agents, such as parasitical growths.

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[6] Professor Gubler's attention having been confined to the phenomenon of dryness, he failed to discern the real cause at work. He, in fact, candidly records his failure.

XLIV.—CONTRIBUTIONS TO THE STUDY OF NERVE ACTION IN CONNEXION WITH THE SENSE OF TASTE. II.—FUNCTIONS OF THE CHORDA TYMPANI. By GEORGE SIGERSON, M.D., Ch. M., F.L.S.

[Read, February 9, 1880.]

IN the preceding Paper certain facts have been demonstrated with respect to the functions of nerves supplying the tongue and buccal cavity. From these facts the following conclusions, amongst others, may be deduced:—

The so-called gustatory nerve is not exclusively, if at all, a nerve of taste. It exercises, as I have proved, a remarkable influence over the epithelial cells of the tongue. When its action is annulled by paralysis, there is retardation or arrest in the elimination of these cells. Hence the conditions necessary for the proper performance of the function of taste are disturbed; a film of effete matter, which, in other circumstances, would have been shed off, now remains, and interposes between the sapid substance and the taste organ. In this manner, the acuteness of the sense of taste might become dulled or diminished to a considerable extent, after paralysis of the "gustatory" nerve, without that diminution going to prove that this nerve is in truth a nerve of taste. Even if we supposed it to be merely a trophic nerve (which I by no means affirm), there would necessarily be some loss of taste, if paralysis prevented the accomplishment of its trophic work.

The continuance of the power of tasting in the anterior portion of the tongue after paralysis, and even after section of the gustatory or lingual nerve, compels us to regard the chorda tympani as the principal nerve of taste in this region. The question of its action is involved in considerable obscurity, and it can scarcely be said that its constitution has yet been definitely demonstrated. Bérard declared that the chorda tympani was an enigma propounded to the sagacity of physiologists. Recently Béclard has pointed out that, "whilst many suppositions have been made concerning the rôle of this singular nerve, it must be confessed that more than one obscurity remains to be cleared up in connexion with it."[1]

Again, whilst some physiologists consider that it obtains its taste-filaments from the facialis (thus making the latter to be a nerve of taste), others maintain that the fibres so obtained were previously borrowed by the facialis from the glosso-pharyngeus or the trigeminus. Against the first-mentioned opinion I adduced the fact that, in a case of absolute facialis-paralysis of one side, arising from pontine

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[1] Béclard, *Traité de Physiologie.* Paris, 6e édition, p. 1016.

...on, taste was not abolished, nor noticeably diminished in the corre-sponding region of the tongue, as would have necessarily happened if the facialis had furnished taste-filaments.

Bellingeri was, it would seem, the first to attribute an active rôle, in the function of taste, to the chorda tympani. His opinion has been confirmed by the experiments of Moos, who has pointed out that, in cases in which compression of the chorda tympani was caused by certain operations in the ear, transient loss of taste supervened. In the case of a patient from whom one half of the inferior maxilla had been removed, together with the chorda tympani and the facialis at its exit from the stylo-mastoid foramen, the gustatory nerve being preserved, the sense of touch persisted on the corresponding anterior portion of the tongue, but the sense of taste had disappeared. This experiment, however, did not differentiate the function of the chorda tympani from that of the facialis. When the chorda tympani is divided, in animals, it is found that the sense of taste is obscured, but the sense of touch remains.

The abstraction of a factor, though it may suffice to solve some problems, is not capable of supplying satisfactory answers to the complex questions which we have to deal with in this instance. In order to understand the properties of the nerve in question with some degree of completeness, it is not enough to observe what takes place when its action is annulled, by whatever cause; we must also endeavour to distinguish what phenomena happen when the nerve is stimulated to action. Now, this experiment may be performed on animals; but as animals cannot intelligibly express the gradations of perception obtained through a special sense-organ, the result must of necessity be unsatisfactory—more especially as it yet remains to be shown that their perceptions of sapid impressions are in perfect unison with those of man. Hence, with respect to the case in point, it is requisite to experiment on man.

The agent of excitation which I found most useful was volta-faradaic electricity, following, in this respect, the example of my late distinguished master, Dr. Duchenne (de Boulogne). Having, therefore, employed faradisation in such a manner as to stimulate the chorda tympani, on at least two hundred occasions, I may, I trust, consider that the opportunities of observation have been sufficiently frequent to reduce the risk of error to a minimum. One of the rheophores was placed, immersed in water, in the external meatus; the other was usually applied in the immediate vicinity. The time occupied by each experiment varied from five to twenty minutes; the action of both currents was tested separately; the number of interruptions was varied, and different degrees of intensity, from the feeblest to the strongest that could be borne, were employed.

Finally, in order to clear up some points, and to determine more accurately, if possible, the several phenomena produced, I considered it necessary to personally undergo the experimentation.

The results of these various experiments may be summarised as

follows: Some of them, I may mention, are confirmatory of those mentioned by Dr. Duchenne (de Boulogne), whilst others are additional, and pertain solely to my own observation.

The functions of the chorda tympani, then, as far as can be determined by the results of faradaic stimulation of that nerve on its passage in the ear, may be described as follows:—

1°. The sensation of a peculiar taste is produced, which can only be described as "metallic," to use the term employed by Dr. Duchenne. This taste is not always perceived immediately on excitation of the nerve; occasionally, repeated stimulation is necessary before this sensation is experienced. Some persons, on the contrary, notice it early and constantly, even with a moderate intensity of excitation. Thus different degrees of stimulation are required to cause its production in different individuals.

2°. A sensation of astringency is occasionally experienced. This has been perceived several times by persons on whom I have experimented. When experimenting on myself I observed the same sensation, and recognised that it was due to a peculiar thrill caused by the stimulated nerve.

This fact has not hitherto been described.

3°. A sensation of dryness and roughness over the corresponding region of the tongue is frequently noticed. Here I have to confirm the observation of Dr. Duchenne, with this addition, that I believe we may attribute the production of this roughness on the tongue to the same mechanism which, on similar stimulation, produce roughness on the cutaneous surface (commonly known as "goose-skin"). I found that the power of setting this mechanism at work was lost to a surface-region affected by paralysis of the ulnar nerve. Here, especially in the outer portion of the hand, the skin was smooth and somewhat parchment-like.

4°. A sensation of prickling and numbness, as where a nerve of general sensibility is excited, is a usual consequence of the stimulation. Dr. Duchenne has remarked it. In my experience I have observed that this sensation, although generally affecting the anterior two-thirds of the tongue on the same side with the operation, may, nevertheless, vary in extent and position within certain limits. Sometimes, for instance, but a small area may be first affected, and a gradual enlargement of area may go on until the entire of the corresponding region be included. In most cases, this may require only a few minutes; but, in some, repeated stimulations may be necessary. In one case I observed that, whilst on one side the anterior two-thirds were affected by this sensation, on the other only a circumscribed region (say, the middle third on that side) was affected: the area increased, under the influence of repeated stimulations, but never quite advanced to the tip of the tongue. Lastly, in another instance, the result of the stimulation was invariably to produce, amongst other things, a tickling irritation in the throat, which was followed by a short dry cough.

Can we explain the diversities of effect described by supposing a

certain diversity in the distribution of the terminal nerve-filaments?

5°. Stimulation of the chorda tympani, when sufficiently strong, causes a flow of saliva into the buccal cavity from the sub-maxillary glands. This phenomena is in conformity with the discovery of Claude Bernard, that section of the chorda determines cessation of secretion in this gland—a discovery which demonstrated the existence of a filament of communication with the sub-maxillary gland, which Cruveilhier had disputed. Dr. Duchenne (de Boulogne) has stated that he did not notice this salivation until his attention had been called to Claude Bernard's experiment, and even then but rarely. For myself, I have frequently observed the occurrence of this phenomenon (which is not, however, constant). This was due, in part, I have no doubt, to the fact that I found it possible to use more stimulant power than he was in the habit of employing.

6°. Finally, I have ascertained that excitation of the chorda tympani is occasionally represented by motion in the region of the tongue supplied by the nerve operated on. Care was, of course, taken to exclude all sources of error from involuntary movements of the tongue. This phenomenon was not discovered by Dr. Duchenne (de Boulogne), owing, doubtless, to the slight intensity of the current he employed in such cases; nor has it been noticed in experiments on animals. However, after having carefully studied the production of slight tremulation in the case of others (and sometimes a certain alteration of shape in the tongue), under the influence of strong stimulation of the nerve in question, I controlled and verified the results by experiments on myself. Consequently, I believe, it may be accepted as a fact, that stimulation of the chorda tympani causes not only sensations of taste, astringency, dryness, roughness, prickling, to be produced, as likewise salivation, but that it also causes the production of a certain feeble motion—in other words, that it is not only a nerve of special and general sensibility, and of secretion, but also that it possesses some few feeble motor filaments, which may, in fact, be derived from the facialis, from which it obtains no taste-filaments.

XLV.—The Application of Spectrum Analysis to the Estimation of Bile in the Renal Secretion of Patients suffering from Jaundice. By F. J. B. Quinlan, M.D., Univ. Dubl., Fellow of the King and Queen's College of Physicians, and Physician to St. Vincent's Hospital.

[Read, January 26, 1880.]

For some time past efforts have been made by physicians and physiologists to introduce into their respective branches tests and measures of precision, in lieu of the vague and approximate observations of the unaided senses; and this movement has led to excellent results. The action of the heart is now recorded graphically by the sphygmograph; respiration is similarly delineated; the rapidity of the circulation is exactly measured; and albumen or diabetic sugar (existing as abnormal constituents of the urine) are expeditiously and accurately estimated by the Jellett saccharimeter—which is by far the best of this class of instruments. I am permitted by the kindness of your Council to submit to your consideration what appears to me to be a contribution to this movement in the form of a simple and effectual test for detecting the presence of bile (or, at least, its colouring matter) in the urine of patients suffering from jaundice; and of approximately estimating its increase or decrease (according as the patient gets better or worse) in the same individual. I say "approximately in the same individual," for the bile is not a secretion of definite strength. About two[1] pounds of it are secreted daily in an ordinary healthy person; but its quality varies, not only in different persons, but in the same person at different times. For this reason we cannot establish an absolutely quantitative formula; but we are certainly able to watch the increase or decrease of the colouring matter in the urine of the same jaundiced patient. The qualitative tests at present most employed in medical practice are those of Gmelin and of Pettenkoffer; but neither are perfectly reliable. In Gmelin's test a drop of nitric acid is let fall on a thin layer of the suspected urine, which has been allowed to flow upon a white plate; and if bile be present an iridescence is produced, beginning with green, and running into blue, violet, red, and yellow; but this will also occur in the presence of the indigo[2] forming matter occasionally found in the urine as a concomitant of carcinomatous disease and diseases of mal-nutrition. In Pettenkoffer's method a peculiar violet brown colour is developed by the action of sulphuric acid and cane sugar upon urine containing bile; but even here there are sources of error in connexion with the presence of albumen, turpentine, or

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[1] Burdon Saunderson, 1879.

[2] This used to be supposed to be identical with the vegetable indigo principle *Indican;* but Hoppe Seyler has shown that it is rather different. It is derived from Indol [C_8H_7N], and its formula is $C_8H_6N\,SO_4\,K$. The defect in Gmelin's test has been described by Carter, and more recently by W. G. Smith.

certain essential oils. It will thus be seen that a simple and reliable test of the colouring matter of bile is a desideratum; and the one I propose is founded on the fact that this colouring matter possesses a power of selective absorption of the solar spectrum, commencing with the violet, and extending (according to the quantity present) nearly as far as Frauenhofer line D. Further, that this colouring matter does not produce any absorptive bands, nor interfere with the red end of the spectrum. After many trials I found that this test is best employed by placing in front of the slit a stratum of fluid of 3*mm.* in thickness; a thinner one has not sufficient absorptive power, and a thicker is not so delicate—a very deep stratum (even though the solution be weak as regards bile) produces a coarse obscuration not suitable for the test. So many skilled observers are now employed in every branch of medical research, especially in Germany, that it is not impossible that this test may have been already described by somebody else. I do not, however, see any mention of it in Neubauer and Vogel on the Urine, or in Frerichs on the Liver; and the exhaustive and admirable work on Physical Diagnosis of Guttmann of Berlin, just issued by the Sydenham Society, is equally silent. I first observed it some years ago when examining jaundiced urine with a small spectroscope, exhibiting two conterminous and independent spectra lighted from different sources; and I found the test so useful for clinical teaching purposes, that I procured a larger instrument specially adapted for its development. In fact, with a Jellett saccharimeter and this instrument a clinical teacher is able to test most delicately for albumen, diabetic sugar or bile, and to estimate the two former exactly, and the latter approximately—and all this with much less trouble and less loss of time than in the ordinary coarse clinical procedures. Returning to the bile test, I wish to mention that it is not my intention on the present occasion to discuss its medical value—a subject more congenial to a purely medical society. For the present I will assume that it is important to the physician to be able to detect bile in the urine in jaundiced patients, and to watch its increase or decrease; and, having made this assumption, will describe the details of the test, and respectfully invite the opinion of this eminent scientific body on its strictly scientific aspect. The instrument is a single prism one, the telescope of which is furnished with a fine needle[1] in the eye-piece, and revolves (with a coarse and fine adjustment) on a segment of the ordinary degree circle—the collimating tube having before the slit a means of holding a thin, flat glass test-tube of 2*mm.* in thickness. Minutes as well as degrees can be read off by the aid of an ordinary vernier. I place this instrument on my laboratory bench, in front of a window, in such a manner that, while the needle is resting on some definite Frauenhofer line, as far back in the violet as possible, the zero of the vernier may point exactly to some degree. In the present instance

[1] This needle was first suggested by Professor O'Reilly, M.R.I.A., of the College of Science, Dublin; and is, in my opinion, superior to any of the usual means of spectrum measurement.

the degree pitched upon was 51°, and the Frauenhofer a well-known line between F and G, which I designate (little) g. Having now either fixed the instrument permanently to the bench, or else very accurately marked out its position, a permanent working constant is established; for when the instrument is in its exact place, and the zero rests on the selected degree, the observer may be sure (even when working by artificial light) that the needle points to the position corresponding to g. Should the observer be working in a strange place, and without sunlight, there is a bright potassum line on the violet side of g, which will give an equally good constant, and may even be made by a previous observation to determine g. The total range of the spectrum of my testing instrument from g in the violet to B in the red is 3° 38′; of which average human bile absorbs 2° 23′, leaving 1° 15′ (or a small fraction more than one-third) of the spectrum unaffected. In human bile the golden red colouring matter, known as Bilirubin $C_{16}H_{18}N_2O_3$ predominates; but in that of the ox and sheep the green Biliverdin [$C_{16}H_{20}N_2O_5$, or according to Maly $C_{16}H_{18}N_2O_4$] is in the ascendant, sheep bile being the greener of the two. It is therefore interesting to find that the absorptive co-efficients of these biles exhibit corresponding differences—that of the ox absorbing 2° 13′, and that of the sheep 2° 7′, as compared with the 2° 23′ of human bile. I now proceeded to examine the effect of aqueous solutions of bile of gradually increasing strength; and for this purpose, on account of the difficulty of obtaining perfectly fresh human bile in quantity, used fresh ox bile. The weakest solution which produced any perfectly definitive effect on my instrument was 5 per cent.; which was of a very pale straw-colour, and exhibited an absorption of 6′. Submitting solutions of gradually increasing strength and colour, I found that there was an increase of about 8′ for every 5 per cent. of bile up to 75 per cent., when the solution scarcely differed in appearance or opacity from pure bile, and produced an absorption of only 20′ less than that of the pure secretion (2° 13′). The shadow thus produced was of an olive greenish black, greener than that of blood (which I shall presently describe); different from any other shadow that I am acquainted with; and, in my experience, pathognomonic of the colouring matter of bile. And I may add that, in many instances, the daily observations of the increase or decrease of bile colouring matter, so made, has been most useful for diagnostic purposes. The cardinal point, however, connected with this test is, that bile, from its weakest solution up to absolute purity, does not exhibit any separate absorptive bands or touch the red end of the spectrum; and the importance of this point I will presently explain.

To establish the value of the test, however, it is essential to inquire whether any of the normal or abnormal constituents of the urine, except bile, possesses this special absorptive power. I have searched long and carefully into this question, but with a negative result. Commencing with the colloids, albumen has no effect upon the spectrum, nor have pus or mucus. Blood is frequently found, as a

haemorrhagic product, in the urine; and its spectrum requires attention and comparison. Arterial blood, in the thin layer of solution, absorbs a small portion of the violet end, and venous blood still more; but in arterial blood we find the two well-known oxyhaemoglobin absorptive lines between D and E, and in venous blood the equally well-known single dark absorption line of reduced haemoglobin nearer the red. Blood, moreover, has a very slight but distinct absorptive power in the red end. Bile, as I have mentioned before, only absorbs the violet end, has no separate absorption lines, and does not in the least affect the red. The microscopical and chemical detection of blood is easy; but, even with the spectroscope alone, there is no difficulty in this differentiation; and I have again and again detected the blood lines (either arterial or venous) in instances where blood became accidentally mixed with the bile in the process of removal. The bile absorption (in solutions of equal strength) overlaps the blood (violet) absorption; and there is no difficulty in detecting both blood and bile in the same specimen; for accuracy, however, pure solutions of either are preferable. Diabetic sugar or the crystalloids have no effect whatever on the solar spectrum.

It is now believed by physiologists that the source of the colouring matter of the bile is the disintegration of the red corpuscles which takes place in the spleen. This belief is principally founded on the fact that the injection of haemoglobin into the blood-vessels of a living animal causes a great effusion of bile colouring matter into the urine, and increases the quantity of Bilirubin in the bile. It appears to me that the fact of haemoglobin, in addition to its characteristic absorptive bands, absorbing the violet end of the spectrum like bile, is confirmatory of the present physiological view as to the nature of bile colouring matter.

Nothing could be more unlike the yolk of an egg, rich in proteids, than the bile, which contains none; and yet it has always appeared to me that there was a certain similarity between the golden-coloured bile and the golden yellow colouring matter of the yolk; and I have long thought both were derived from disintegrated haemoglobin. On applying my test to the yolk, emulsified with three times its own quantity of water, I find it has an absorption nearly identical with that of bile. The yolk, so treated, absorbs 2° 5′ of the violet end of the spectrum, and without absorption bands. Here we have an interesting chain of reasoning. We cannot synthetically make Bilirubin, but we can do so indirectly by injecting haemoglobin into the blood of a living animal, and thus produce a haemoglobin derivative, which will absorb the violet. Does it not seem possible that the colouring matter of the yolk is a similar haemoglobin derivative?

I make this suggestion, however, in a purely tentative spirit, and without in the least expressing an opinion as to its accuracy or otherwise. In this communication I wish to confine myself strictly to my bile test. The conclusions which appear derivable from it are as follow:—

.. an easy and reliable qualitative test of the presence of the matter of bile in the urine is afforded by placing a 3mm. .. the suspected fluid before the slit of the spectroscope, and whether the special absorption, which I have described,

no other normal or abnormal constituent of the urine .. special absorption.

. ..at to so examine such suspected urine, by the bedside of the ..nt, with one of the small but effectual spectroscopes, which are .... so constructed as to be easily carried in the waistcoat pocket, is a ..edure as quick and easy as Gmelin's test, and quicker and easier .. Pettenkoffer's. I believe it to be more reliable than either.

4. That the daily increase or decrease of the absorption (in the same individual) is capable of approximately indicating the increase or decrease of the biliary colouring matter in the urine; and, *pro tanto*, the extent of the excretion of bile through that channel.

5. That this test affords an additional proof of the present physiological opinion, that biliary colouring matter is a haemoglobin disintegration derivative.

Demonstrations of the various spectra described were given.

NOTE ADDED IN THE PRESS.

Since the reading of this Paper Dr. Charles A. MacMunn's new work, "The Spectroscope in Medicine," has come to hand. This volume abounds in original research, and contains information of the most valuable and practical kind; it does not, however, describe this particular test for bile.

At the suggestion of Dr. G. Sigerson, M.R.I.A., the author has tried whether the acidity or alkalinity of the icteric urine altered its peculiar absorptive power; and he finds that it does not.

XLVI.—EXPERIMENTS MADE TO DETERMINE THE "DRAG"[1] OF AIR UPON AIR AND OF WATER UPON WATER AT LOW VELOCITIES. By the REV. SAMUEL HAUGHTON, M.D., D.C.L., and J. EMERSON REYNOLDS, M.D.

[Read, February 23, 1880.]

A SPHERICAL ball of granite, unpolished, was suspended by a pianoforte wire, and allowed to hang freely; from the brass collar by which the ball was suspended an index projected on each side, the pointed ends of the indices traversing a graduated horizontal circle, whose centre corresponded with the line of suspension. The suspended ball was immersed in water contained in an iron tub.

The weight of the granite ball was 22452·85 grams, and its mean diameter was 251·46 millimeters. The length of the wire of suspension was 610·8 centimeters, and its diameter was 0·889 millimeter. The diameter of the iron tub was 2 ft. 4 in., and the depth of water contained in it was 1 ft. 9 in.

The method of observation was as follows: the indices of the ball having arrived at the zero of rest, the ball was then displaced by a torsional movement of the wire, and allowed to regain its position of rest by a succession of vibrations of diminishing amplitudes.

The quantities observed were, the time of vibration and the rate of diminution of the amplitude.

The equations of motion of the apparatus are thus found:—

$$\frac{d^2x}{dt^2} - X = 0; \qquad (1)$$

where x = the varying amplitude of any point of the surface of the ball measured from the zero of rest;

X = the tangential forces of torsion and "drag" acting at the point x.

If we assume that for low velocities the friction will be proportional to the velocity, we shall have

$$X = k^2x - f\frac{dx}{dt}; \qquad (2)$$

where k is a coefficient depending on torsion, and f is a coefficient depending on "drag."

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[1] By the term "Drag," I understand the combined effects of Friction and Viscosity.

-y to see that the complete integral of the equation of

$$\frac{d^2x}{dt^2} + f\frac{dx}{dt} + k^2x = 0, \tag{3}$$

of the form

$$x = ae^{mt}\cos nt + be^{mt}\sin nt, \tag{4}$$

here a and b are arbitrary constants, and where m and n have the values

$$m = -\frac{f}{2}; \qquad n = \sqrt{k^2 - \frac{f^2}{4}}. \tag{5}$$

If we reckon the time from the commencement of the oscillation, equation (4) reduces to

$$x = ae^{mt}\cos nt. \tag{6}$$

If T denote the time of a complete double oscillation, we find from the above

$$\theta_n = \theta_o e^{-\frac{fnT}{2}}, \tag{7}$$

where

θ_n = amplitude of the $(n+1)^{th}$ vibration;
θ_o = amplitude of the first vibration.

From (7) we obtain the following working equation, for use in the calculations to determine the coefficient of friction :—

$$f = \frac{2}{nT}\log_e\left(\frac{\theta_o}{\theta_n}\right). \tag{8}$$

Also, we have,

$$n = \frac{2\pi}{T} = \sqrt{k^2 - \frac{f^2}{4}};$$

from which we obtain, after some reductions,

$$T = \frac{4\pi}{\sqrt{4k^2 - f^2}}. \tag{9}$$

If we introduce into this equation the value of f determined by (8), we obtain k, which depends on the torsion only.

T = 1·51 MINUTE.

Details of Experiments on Air.

1. 28*th May*, 1879 :—

Hour.	n = vibrations, number of complete.	θ = amplitude of whole arc.
9 A.M.	00°·0	130°·0
10 ,,	39 ·8	99 ·0
11 ,,	[illegible]	[illegible]·0
Noon,	1[illegible]	[illegible]·5
1 P.M.	1[illegible]	[illegible]·5

From these data I find—

First hour, . . . [illegible] ÷ 6626
Two hours, . . . [illegible] 5564
Three ,, . . . [illegible] 6487
Four ,, . . . [illegible] 6590

Mean of all, . [illegible] $\frac{1}{[illegible]17}$.

2. 30*th May*, 1879 :—

Hour.	[illegible]	θ
0	00°·0	92°·00
1	39 ·8	68 ·70
2	79 ·5	50 ·20
3	119 ·2	38 ·90
4	159 ·0	30 ·50
5	198 ·7	22 ·00
6	238 ·4	16 ·85
7	278 ·2	12 ·75

From these data I find—

One hour, ... $f = 1 \div 6191$
Two hours, ... ,, 5952
Three ,, ... ,, 6278
Four ,, ... ,, 6532
Five ,, ... ,, 6299
Six ,, ... ,, 6735
Seven ,, ... ,, 6384

Mean of all, ... $f = \frac{1}{6339}$.

3. 31*st May*, 1879:—

Hour.	π	θ
0	00°·0	92°·75
1	39 ·8	68 ·25
2	79 ·5	49 ·50
3	119 ·2	37 ·50
4	159 ·0	26 ·75
5	198 ·7	21 ·00

From these data I find—

One hour, ... $f = 1 \div 5885$
Two hours, ... ,, 5742
Three ,, ... ,, 5970
Four ,, ... ,, 5799
Five ,, ... ,, 6067

Mean of all, ... $f = \frac{1}{5893}$.

4. 13*th June*, 1879:—

Hour.	π	θ
0	00°·0	100°·00
1	39 ·8	71 ·75
2	79 ·5	54 ·50
3	119 ·2	39 ·40
4	159 ·0	31 ·25

From these data I find—

One hour, ... $f = 1 \div 5437$
Two hours, ... ,, 5940
Three ,, ... ,, 5804
Four ,, ... ,, 6200

Mean of all, ... $f = \frac{1}{5845}$.

14*th June*, 1879 :—

Hour.	η	θ
h. m.		
0·00	00°·0	100°·00
1·00	39 ·8	74 ·25
2·30	99 ·3	47 ·25
3·30	139 ·0	35 ·50
4·30	179 ·0	26 ·00

From these data I find—

One hour, ... $f = 1 \div 6062$
Two and a-half hours, ... ,, 6007
Three ,, ,, ... ,, 6087
Four ,, ,, ... ,, 6027

Mean of all, ... $f = \frac{1}{6046}$.

6. 16*th June*, 1879 :—

Hour.	η	θ
h. m.		
0·00	00°·0	100°·00
1·00	39 ·8	73 ·75
2·00	79 ·5	55 ·00
3·00	119 ·2	39 ·00
4·00	159 ·0	29 ·00
4·30	179 ·0	25 ·00

From these data I find—

One hour, ... $f = 1 \div 5928$
Two hours, ... ,, 6031
Three ,, ... ,, 5741
Four ,, ... ,, 5826
Four and a-half hours, ... ,, 5856

Mean of all, ... $f = \frac{1}{5876}$.

I have no doubt, from the close agreement of the results of each day's experiments, that the differences observed from day to day are real, and depend upon the varying temperature and pressure of the atmosphere: but, as my present object is only to find a general mean

value for the "drag" of air upon air, I shall take the average of the six days, which give us—

$$\frac{1}{f}:$$

1. 28th May, 1879,	. . . .	6317
2. 30th " "	. . . .	6339
3. 31st " "	. . . .	5893
4. 13th June, "	. . . .	5845
5. 14th " "	. . . .	6046
6. 16th " "	. . . .	5876

Mean of all, ... $f = \dfrac{1}{6052 \cdot 7}$.

T = 1·56 Minute.[1]

Details of Experiments on Vartry Water.

1. *3rd July*, 1879.—Observed by Dr. Reynolds, using single readings of one index:—

n	θ	Combination.	$\frac{1}{f}$
0	110°·00		
1	95 ·00		
2	81 ·00		
3	69 ·00		
4	58 ·50		
5	50 ·50		
6	42 ·50	(0, 6)	$\frac{1}{295 \cdot 6}$
7	36 ·50		
8	31 ·00		
9	26 ·25		
10	22 ·50		
11	19 ·00		
12	16 ·00	(0, 12)	$\frac{1}{291 \cdot 6}$
Mean, ... $f = \frac{1}{293 \cdot 6}$.			

[1] Some alterations (of a slight kind) had been made in the mode of suspension of the ball, after the trials in air.

. *May*, 1879 :—

Hour.	n	θ
0	00°·0	92°·75
1	39 ·8	68 ·25
2	79 ·5	49 ·50
3	119 ·2	37 ·50
4	159 ·0	26 ·75
5	198 ·7	21 ·00

From these data I find—

One hour, ...	$f = 1 \div 5885$
Two hours, ...	„ 5742
Three „	„ 5970
Four „	„ 5799
Five „	„ 6067

Mean of all, ... $f = \frac{1}{5893}$.

4. 13*th June*, 1879 :—

Hour.	n	θ
0	00°·0	100°·00
1	39 ·8	71 ·75
2	79 ·5	54 ·50
3	119 ·2	39 ·40
4	159 ·0	31 ·25

From these data I find—

One hour, ...	$f = 1 \div 5437$
Two hours, ...	„ 5940
Three „	„ 5804
Four „	„ 6200

Mean of all, ... $f = \frac{1}{5845}$.

5. 14*th June*, 1879 :—

Hour.	n	θ
h. m.		
0·00	00°·0	100°·00
1·00	39 ·8	74 ·25
2·30	99 ·3	47 ·25
3·30	139 ·0	35 ·50
4·30	179 ·0	26 ·00

From these data I find—

One hour, ... [illegible] 1 ÷ 6062
Two and a-half hours, . [illegible] 6007
Three ,, ,, [illegible] 6087
Four ,, ,, [illegible] 6027

Mean of all, . . [illegible] $\frac{1}{[illegible]46}$.

6. 16*th June*, 1879 :—

Hour.	[illegible]	[illegible]
h. m.		
0·00	[illegible]	[illegible]°·00
1·00	[illegible]	[illegible]3 ·75
2·00	79 ·5	55 ·00
3·00	119 ·2	39 ·00
4·00	159 ·0	29 ·00
4·30	179 ·0	25 ·00

From these data I find—

One hour, ... f = 1 ÷ 5928
Two hours, ... ,, 6031
Three ,, ... ,, 5741
Four ,, ... ,, 5826
Four and a-half hours, ... ,, 5856

Mean of all, ... $f = \frac{1}{5876}$.

I have no doubt, from the close agreement of the results of each day's experiments, that the differences observed from day to day are real, and depend upon the varying temperature and pressure of the atmosphere: but, as my present object is only to find a general mean

"drag" of air upon air, I shall take the average of all —fs, which give us—

$\frac{1}{f}$:

1.	28th May, 1879,	6317
2.	30th " "	6339
3.	31st " "	5893
4.	13th June, "	5845
5.	14th " "	6046
6.	16th " "	5876

Mean of all, ... $f = \frac{1}{6052 \cdot 7}$.

T = 1·56 Minute.[1]

Details of Experiments on Vartry Water.

1. *3rd July*, 1879.—Observed by Dr. Reynolds, using single readings of one index :—

n	θ	Combination.	$\frac{1}{f}$
0	110°·00		
1	95 ·00		
2	81 ·00		
3	69 ·00		
4	58 ·50		
5	50 ·50		
6	42 ·50	(0, 6)	$\frac{1}{295 \cdot 6}$
7	36 ·50		
8	31 ·00		
9	26 ·25		
10	22 ·50		
11	19 ·00		
12	16 ·00	(0, 12)	$\frac{1}{291 \cdot 6}$
Mean, ... $f = \frac{1}{293 \cdot 6}$.			

[1] Some alterations (of a slight kind) had been made in the mode of suspension of the ball, after the trials in air.

2. *2nd July*, 1879.—Observed by Dr. Reynolds, using single readings of one index :—

n	θ		$\frac{1}{f}$
0	98°·00		
1	85 ·00		
2	72 ·50		
3	62 ·50		
4	53 ·50		
5	46 ·00		$\frac{1}{309·7}$
6	40 ·00		
7	34 ·00		
8	29 ·00		
9	25 ·25		
10	21 ·25		$\frac{1}{306·5}$
11	18 ·00		
12	16 ·00		
13	13 ·00		
14	11 ·50		
15	10 ·60	(0, 15)	$\frac{1}{307·9}$
16	8 ·00		

Mean, ... $f = \frac{1}{308·03}$.

uly, 1879.—Observed by Dr. Macalister and self, using readings of one index :—

u	θ	Combination.	$\frac{1}{f}$
0	101°·25		
1	87 ·50		
2	75 ·50		
3	65 ·00		
4	55 ·00		
5	48 ·75		
6	41 ·25	(0, 6)	$\frac{1}{313·1}$
7	35 ·75		
8	29 ·50		
9	26 ·75		
10	22 ·50		
11	18 ·50		
12	17 ·00		
13	15 ·00	(0, 13)	$\frac{1}{318·9}$
Mean, ... $f = \frac{1}{316·0}$			

4. *8th July*, 1879.—Observed by Dr. Macalister and self, using double readings with both indices :—

u	θ	Combination.	$\frac{1}{f}$
0	102°·125		
1	87 ·875	(0, 1)	311·7
2	75 ·375	(0, 2)	308·5
3	64 ·750	(0, 3)	308·5
4	56 ·000	(0, 4)	311·9
5	47 ·875	(0, 5)	309·2
6	41 ·625	(0, 6)	313·2
7	35 ·750	(0, 7)	312·5
8	30 ·750	(0, 8)	312·3
9	26 ·375	(0, 9)	311·5
10	22 ·750	(0, 10)	312·9
Mean, . . . 311·13 ± 0·37 mean probable error.			

ean of the three observations with single readings is,

$$f = \frac{1}{305 \cdot 88},$$

e mean of all the observations made with amplitude θ_o, nearly is

$$f = \frac{1}{308 \cdot 50}.$$ [1]

9th July, 1879.—Observed b[illegible] nd self, using readings with both indices:—

n	θ		$\frac{1}{f}$
0	346°·500		307·0
1	298 ·000		310·7
2	253 ·250		298·9
3	missed		—
4	186 ·500		302·5
5	158 ·670		299·7
6	136 ·870		302·3
7	116 ·750		301·5
8	100 ·620		306·7
9	86 ·250	[illegible]	307·4
10	74 ·250	(5, 10)	308·7
11	63 ·750	(5, 11)	308·3
12	54 ·500	(0, 12)	304·0
13	46 ·875	(0, 13)	304·5
14	40 ·375	(10, 14)	307·7
15	35 ·125	(10, 15)	313·0

Mean, . . . = 305·53 ± 07·1 (mean probable error).

[1] counted the fourth observation with double readings, equal in value to the f the three observations with single readings.

y, 1879.—Observed by Dr. Macalister and self, using readings with both indices :—

n	θ	Combination.	$\frac{1}{f}$
0	346°·750	(0, 16)	306·3
1	295 ·875	(0, 15)	306·9
2	254 ·375	(0, 14)	308·5
3	217 ·500	(0, 11)	307·3
4	187 ·625	(0, 4)	305·1
5	160 ·625	(0, 5)	304·4
6	137 ·375	(0, 6)	303·6
7	118 ·500	(0, 7)	305·4
8	102 ·500	(0, 8)	307·5
9	88 ·000	(5, 9)	311·5
10	75 ·750	(5, 10)	311·7
11	64 ·825	(5, 11)	309·8
12	55 ·250	(0, 12)	306·1
13	48 ·125	(0, 13)	308·4
14	41 ·375	(10, 14)	309·9
15	35 ·125	(10, 15)	304·8
16	30 ·000	(10, 16)	304·2
Mean, ... 307·14 ± 0·41 (mean probable error).			

The mean of this and the preceding Table is

$$f = \frac{1}{306{\cdot}335}$$

for amplitudes ranging up to 360°. The mean value of f, from all the experiments, is as follows :—

	$\frac{1}{f}$:
Mean value of 1, 2, 3, 4, ...	308·50
Mean value of 5, ...	305·53
Mean value of 6, ...	307·14
Mean of all, ...	307·057

From the preceding value of f we can determine the relation between the slope of a water-surface and its velocity. We have, for the equation of motion of the surface,

$$\frac{d^2x}{dt^2} = g \sin i - f\frac{dx}{dt}; \tag{10}$$

where g denotes the force of gravity, i the slope of the surface, and x the distance of any particle from the origin measured in the direction of the motion. If v denote the velocity of a particle, equation (10) becomes at once

$$\frac{dv}{dt} + fv = g \sin i; \tag{11}$$

which gives, by integration,

$$e^{ft}(g \sin i - fv) = \text{const.} \tag{12}$$

This indicates that the velocity will increase from zero up to the value given by

$$g \sin i - fv = 0, \tag{13}$$

after which it will remain constant for ever.

The final constant velocity given by equation (13) is

$$v = \frac{g \sin i}{f} = 32{\cdot}2 \times 307{\cdot}057 \sin i. \tag{14}$$

If we express the velocity in feet per second, and call h the slope per mile, we find

$$v = 1{\cdot}8726 \times h \text{ ft. per second}; \tag{15}$$

which is equivalent to

$$v = 30{\cdot}642\ h \text{ miles per day}. \tag{16}$$

Dr. Carpenter has proposed to explain the phenomena of ocean circulation by the greater height of the water at the equator as compared with that at the poles.

If we call the distance from the equator to the pole 6000 miles, and suppose the velocity of the surface current towards the pole to be only one mile per day, we find from equation (16), that this would require a head of water at the equator

$$h = 195{\cdot}80 \text{ feet}.$$

No such difference of level can be admitted between the equilibrium levels of the equatorial and polar oceans.

est accurate estimate of the difference is that made
riz., 4½ feet.
..ead of water, if it could produce an oceanic flow at a
one at the rate of one mile in 42·567 days; or a flow th
would occupy 700 years to pass from the equator to the poles.

XLVII.—MATHEMATICAL NOTES. By A. H. ANGLIN.

[Read, January 12, 1880.]

ABSTRACT.

I.

If $a_1, a_2, a_3, \ldots a_m$ be roots of the equation

$$x^m = p_1 . x^{m-1} + p_2 . x \quad \ldots \quad \ldots + p_m,$$

then

$$h_n = p_1 . h_{n-1} + p_2 . h_n \quad \ldots \quad + p_m . h_{n-m} \; (n > m),$$

where h_n is the sum of the hom ... $a_1, a_2, a_3 \ldots a_m$ *of n dimensions.*

The proof of this may be bri ... :—

We have

$$x^m - p_1 . x^{m-1} - p_2 . x^{m-2} - \ldots \quad \ldots - a_2) \ldots (x - a_m).$$

Writing $\frac{1}{x}$ for x, multiplyi ... d finally equating coefficients of x^n in both members of the equation, we shall find that

$$h_n - p_1 . h_{n-1} - p_2 . h_{n-2} - \ldots - p_m . h_{n-m} = 0 ;$$

or,

$$h_n = p_1 . h_{n-1} + p_2 . h_{n-2} + p_3 . h_{n-3} + \ldots + p_m . h_{n-m}.$$

The particular case of a quadratic equation is then noticed. If α, β be roots of $x^2 = px + q$, we have

$$h_n = p . h_{n-1} + q . h_{n-2},$$

where h_n is the sum of the homogeneous products of α, β of n dimensions. From this it is deduced that

$$h_{2n} = p^{2n} + (2n-1) . p^{2n-2} . q + \frac{(2n-2)(2n-3)}{1 . 2} . p^{2n-4} . q^2$$
$$+ \frac{(2n-3)(2n-4)(2n-5)}{1 . 2 . 3} . p^{2n-6} . q^3 + \ldots + \frac{(n+1) . n}{1 . 2} . p^2 . q^{n-1} + q^n$$
$$\ldots \ldots \quad (1)$$

$$\ldots^{+1} + 2n \, . \, p^{2n-1} \, . \, q + \frac{(2n-1)(2n-2)}{1\,.\,2} \, . \, p^{2n-3} \, . \, q^2$$

$$\frac{(2n-3)(2n-4)}{1\,.\,2\,.\,3} \, . \, p^{2n-5} \, . \, q^3 + \ldots + \frac{(n+2)(n+1) \, . \, n}{1\,.\,2\,.\,3} \, . \, p^3 \, . \, q^{n-1}$$

$$+ (n+1) \, . \, p q^n \ \ldots \ , \quad (2)$$

each of which series consists of $n+1$ terms.

Conversely, the sums of the series (1) and (2) are known; for they are, respectively, h_{2n} and h_{2n+1}, i. e.,

$$(\alpha^{2n+1} - \beta^{2n+1}) \div (\alpha - \beta),$$

and

$$(\alpha^{2n+2} - \beta^{2n+2}) \div (\alpha - \beta).$$

Finally, h_n is expressed under another form, viz.:—

$$h_n = p^r \, . \, h_{n-r} + r \, . \, p^{r-1} \, . \, q \, . \, h_{n-r-1} + \frac{r \, . \, (r-1)}{1\,.\,2} \, . \, p^{r-2} q^2 \, . \, h_{n-r-2} + \ldots$$

$$+ q^r \, . \, h_{n-2r};$$

which may be expressed symbolically thus:—

$$h_n = (p+q)^r \, . \, [h]^{n-r}_{n-2r} \, .$$

II.

If $x^m = p_1 \, . \, x^{m-1} + p_2 \, . \, x^{m-2} + p_3 \, . \, x^{m-3} + \ldots + p_m$, *to express* x^n $(n > m)$ *in form*

$$P_1 \, . \, x^{m-1} + P_2 \, . \, x^{m-2} + P_3 \, . \, x^{m-3} + \ldots + P_m.$$

A particular case is first considered. If $x^4 = px^3 + qx^2 + rx + s$, to express x^n in the form

$$Px^3 + Qx^2 + Rx + S.$$

We may briefly indicate the solution thus:—

Multiplying both sides of equation $x^4 = px^3 + qx^2 + rx + s$ by x, and arranging the terms, we shall find

$$x^5 = h_2 \, . \, x^3 + (qh_1 + r)x^2 + (rh_1 + s)x + sh_1.$$

Repeating this process, we shall find by the application of (I)—

$$x^6 = h_3 . x^3 + (qh_2 + rh_1 + s) . x^2 + (rh_2 + sh_1) . x + s . h_2,$$

where h_n is the sum of the homogeneous products of roots of $x^4 = px^3 + qx^2 + rx + s$ of n dimensions.

Finally, it is shown by the process of Mathematical Induction, and the repeated application of (I), that

$$x^n = h_{n-3} . x^3 + (qh_{n-4} + rh_{n-5} + s . h_{n-6}) . x^2$$
$$+ (r . h_{n-4} + s . h_{n-5}) . x + s . h_{n-4}.$$

The general case is established in a similar way—

$$x^m = p_1 . x^{m-1} + p_2 . x^{m-2} + \ . \ . \ . \ + p_m.$$

Multiplying both sides of this equation by x, and arranging the terms, we shall find

$$x^{m+1} = h_2 . x^{m-1} + (p_2 h_1 + p_3) . x^{m-2} + \ldots + (p_{m-1} . h_1 + p_m) . x$$
$$+ p_m . h_1.$$

Repeating this process, we shall find by the application of (I),

$$x^{m+2} = h_3 . x^{m-1} + (p_2 h_2 + p_3 h_1 + p_4) . x^{m-2} + \ldots$$
$$+ (p_{m-1} . h_2 + p_m . h_1) . x + p_m . h_2.$$

Finally, it is shown by the process of Mathematical Induction, and the repeated application of (I), that—

If $x^m = p_1 . x^{m-1} + p_2 . x^{m-2} + \ . \ . \ . \ + p_m,$ then

$$x^n (n > m) = h_{n-m+1} . x^{m-1} + (p_2 . h_{n-m} + p_3 . h_{n-m-1} + p_4 . h_{n-m-2} + \ldots$$
$$\ldots + p_m . h_{n-2m+2}) . x^{m-2}$$
$$+ (p_3 . h_{n-m} + p_4 . h_{n-m-1} + \ldots + p_m . h_{n-2m+3}) . x^{m-3}$$
$$+ \ldots\ldots + (p_{m-1} . h_{n-m} + p_m . h_{n-m-1}) . x + p_m . h_{n-m},$$

where h_n is the sum of the homogeneous products of roots of

$$x^m = p_1 . x^{m-1} + p_2 . x^{m-2} + \ldots + p_m,$$

of n dimensions.

EXPLANATION.

the "sum of the homogeneous products of $a_1, a_2, \ldots a_m$ ns" is meant the sum of all the products, each of that can be formed of $a_1, a_2, \ldots a_m$ and their powers is the coefficient of x^n in the development of

$$\frac{1}{1-a_1x}\cdot\frac{1}{1-a_2x}\cdots\frac{1}{1-a_mx},$$

i. e., in the development of

$$(1+a_1x+a_1^2x^2+\ldots)(1+a_2x+a_2^2x^2+\ldots)\ldots(1+a_mx+a_m^2x^2+\ldots)$$

We notice that it includes the *powers* of $a_1, a_2, \ldots a_m$, and it is often expressed more fully thus:—

"The sum of the homogeneous products of $a_1, a_2, \ldots a_m$ and their powers, all of n dimensions."

The *number* of homogeneous products of n dimensions that can be formed out of $a_1, a_2, \ldots a_m$ and their powers is found in the usual way by putting $a_1, a_2, \ldots a_m$ each $= 1$, and is

$$\frac{\lfloor m+n-1}{\lfloor m-1 \lfloor n}.$$

XLVIII.—ON THE SATELLITE OF A LINE MEETING A CUBIC. By WILLIAM R. ROBERTS, M. A.

[Read, April 12, 1880.]

BEFORE entering on the discussion of the equation of the satellite and that of the tangent at the three points in which a given line meets a cubic, it will be found convenient to premise the following theorem:—

Given the equations of two curves of the p^{th} and q^{th} order, respectively,

$$(1).\quad \phi(x\,y\,z) = 0,$$

$$(2).\quad \psi(x\,y\,z) = 0,$$

to form symmetric functions of the pq values which simultaneously satisfy the two equations. Eliminating $x\,y\,z$ between (1) and (2), and the equation of an arbitrary line $lx + my + zn = 0$, we obtain an equation of the pq^{th} degree in $l\,m\,n$, which may be written

$$\Lambda(\phi, \psi) = A_{pq,0,0}\,l^{pq} + A_{pq-1,1,0}\,l^{pq-1}\,m + \ldots \text{ \&c.};$$

then we shall have—

$$A_{pq,0,0} = \kappa\,.\,x_1\,x_2\,\ldots\,x_{pq};$$

$$A_{pq-1,1,0} = \kappa\,.\,\Sigma\,y_1\,x_2\,x_3\,\ldots\,x_{pq};$$

&c., &c.

Having found these fundamental symmetric functions, the formation of others presents no difficulty.

Let $T = 0$ be the equation of the tangents at the points where $L \equiv \lambda x + \mu y + \nu z$ meets the cubic $U \equiv x^3 + y^3 + z^3 + 6m\,xyz$, then we must have—

$$T \equiv \Sigma U - KL^2M,$$

where Σ is the condition that L should touch U and $M \equiv \lambda' x + \mu' y + \nu' z$ is the satellite of L. For, when L touches U, T must reduce to the product L^2M multiplied by a numerical factor K.

The polar conic S of any point $x'y'z'$ on T, U, and L, all pass through a common point. Hence the eliminant of S, L, and U, equated to zero, will express that $x'y'z'$ lies on T. Or,

$$T \equiv (x_1^3 + y_1^3 + z_1^3 + 6m\,x_1y_1z_1)(x_2^3 + y_2^3 + z_2^3 + 6m\,.\,x_2y_2z_2);$$

$x_1y_1z_1$, $x_2y_2z_2$ being values common to S and L. It will be sufficient

ose to calculate the coefficient of x'^3 in T. Forming the equation R (S, L), and putting $y' = z' = 0$, we find—

$$
\begin{aligned}
x_1 x_2 &= -2m\mu\nu x', \\
y_1 y_2 &= \nu^2 x', \\
z_1 z_2 &= \mu^2 x', \\
y_1 z_2 + z_1 y_2 &= -2(\mu\nu + m\lambda^2) x', \\
z_1 x_2 + z_2 x_1 &= 2m\lambda\mu x', \\
x_1 y_2 + y_1 x_2 &= 2m\lambda\nu x'.
\end{aligned}
$$

The coefficient of x'^3 is found to be—

$$
\begin{aligned}
&\mu^6 + \nu^6 - (2 + 32m^3)\mu^3\nu^3 - 18m\lambda^2\mu^2\nu^2 \\
&\quad - 24m^2\lambda\mu\nu(\lambda^3 + \mu^3 + \nu^3) - 8m^3\lambda^6 \\
&\quad - 16m^3\lambda^3(\mu^3 + \nu^3).
\end{aligned}
$$

Now,

$$
\begin{aligned}
\Sigma = {} & \lambda^6 + \mu^6 + \nu^6 - (2 + 32m^3)(\lambda^3\mu^3 + \mu^3\nu^3 + \nu^3\lambda^3) \\
& - 24m^2\lambda\mu\nu(\lambda^3 + \mu^3 + \nu^3) - (24m + 48m^4)\lambda^2\mu^2\nu^2.
\end{aligned}
$$

Substracting the above quantity from Σ, we find—

$$K\lambda^2\lambda' = (1 + 8m^3)\lambda^2\{\lambda^4 - 2\lambda(\mu^3 + \nu^3) - 6m\mu^2\nu^2\}.$$

Hence,

$$
\begin{aligned}
K &= (1 + 8m^3), \\
\lambda' &= \lambda^4 - 2\lambda(\mu^3 + \nu^3) - 6m\mu^2\nu^2, \\
\mu' &= \mu^4 - 2\mu(\lambda^3 + \nu^3) - 6m\nu^2\lambda^2, \\
\nu' &= \nu^4 - 2\nu(\mu^3 + \lambda^3) - 6m\lambda^2\mu^2.
\end{aligned}
$$

The form of these co-ordinates at once suggests the following theorem :—

The satellite of a given line, meeting a system of cubics passing through the inflexions of U, passes through a fixed point.

XLIX.—ON THE DIRECTIONS OF MAIN LINES OF JOINTING OBSERVABLE IN THE ROCKS ABOUT THE BAY OF DUBLIN, AND THEIR RELATIONS WITH ADJACENT COAST LINES. By J. P. O'REILLY, C.E., Professor of Mining and Mineralogy, Royal College of Science, Ireland.

[Read, February 23, 1880.]

WHEN submitting to the Academy, in January, 1879, a memoir upon the correlations of lines of direction on the Earth's surface (vide *Transactions*, vol. xxvi., p. 617), I expressed the hope of being able to bring forward a series of observations in support of the theory therein involved, to be taken, in the first place, from the three kingdoms, the Geology of which has been so thoroughly worked out in most of its details.

During the last two summers I made a series of determinations of directions of main lines of jointing, on the north and south sides of the Bay of Dublin, which I have the honour of submitting to the Academy, with a summary of the consequences which I think are fairly deducible therefrom, and which go in support of the general theory of correlation already referred to.

I have in the first place simply detailed the measurements and observations made, and have then grouped the directions of jointing into series, showing their relations one with the other and with the coast lines.

Commencing at Blackrock, the most northerly outcrop of the Dalkey or Wicklow granites, there occur on the shore, just beside the railway station, patches of granite which extend out in small promontories in a N.E. direction.

One patch of this rock occurs close under the Blackrock station, and forms there part of the sea wall. It presents the constitution of a well-marked granitic Breccia[1] which has not, that I am aware of, any representative in or about the Dublin coast. It evidently represents the consequences of a fracture having taken place in the immediate vicinity, and is in all probability related to the cause which determined the northern limit of the Dalkey granites. This is to a certain extent indicated by the direction[2] of the jointing observed in this granite:—

Blackrock:—

1.	General direction in a rough joint, ...	Nm.	67° W.
2.	Cross jointing, ...	,,	13° E.
3.	Jointing in rocks at ladies' bathing-place, under Idrone-terrace, ...	,,	67° W.
4.	Another jointing in the same place, ...	,,	67° W.

[1] See "Notice of some Remarkable Appearances of the Granite to the South of Dublin," by the Rev. H. Lloyd, F.T.C.D., M.R.I.A., *Proc.* Geol. Soc.: Dublin, Nov. 10, 1833.

[2] The directions in this Table are magnetic. The magnetic variations being, for the date of the observations, about 22° W.

Iill—*continued.*

	sion between old Telegraph Hill and Obelisk general direction, ...	$N^{m \cdot}$	8°–10° E.
	l at Killiney House, contact of granite and schist, ...	,,	46° E.
	ls west of entrance to Killiney Castle, great te dyke, vertical and much banded, . .	,,	24° E.

Killiney Park :—

.	Contact of granite and slate rock, fault (the direction of the contact line runs out between the two Sugar-loaves), ...	,,	39° E.
78.	Joint cutting off the banded granite or gneiss to the east, ...	,,	47°–50° E.
79.	Contact of granite and slate rock at western end in park, ...	,,	42° E.
80.	Contact direction taken on a line $4^{m \cdot}$ from face of joint and parallel to it, about 30 yards long, .	,,	39°–40° E.
	Eurite vein on west side of Park, apparent direction,	,,	26° W.
	,, ,, to the west, near the new Quarries, .	,,	26° W.
[illegible]	Band of Euritic granite here, ...	,,	27° W.
84.	Face of granite joint, well marked, as if of bedding (dip south at 62°), ...	,,	25° W.
85.	Eurite band here, ...	,,	54° W.

Dalkey Island :—

86.	East of Boat Harbour, repeated vertical jointing, .	,,	70° W.
87.	,, ,, ,, great Eurite vein, vertical, $0^{m}\cdot50$–$0^{m}\cdot80$ thick, .	,,	6°–7° W.
88.	,, ,, ,, joint further east, . .	,,	6°–7° W.
89.	,, ,, ,, set of joints, . . .	,,	26°–28° E.
90.	,, ,, ,, ,, ,, ...	,,	28°–30° E.
91.	,, ,, ,, big joint looking towards Bailey Light-house, .	,,	38°–40° E.
92.	On east side, north-east point, joint, ...	,,	43° E.
93.	Near easternmost point, two joints at an interval of $3^{m \cdot}$, ...	,,	42°–43° E.
94.	North-east point, opposite Muglins, set of quartz joints, ...	,,	7°–8° W.
95.	,, ,, ,, Eurite vein with felspar crystals,	,,	23°–24° W.
96.	,, ,, ,, vertical joint at same point, .	,,	7°–7° 30′ W.
97.	Near rocking stone in little inlet, Eurite vein $0^{m}\cdot50$ thick, vertical, . .	,,	22° 30′ W.
98.	,, ,, ,, Eurite vein close by, . .	,,	28°–30° W.
99.	Jointing parallel to south-east coast line, . .	,,	37°–38° E.
100.	Just under Battery, Eurite vein, $1^{m \cdot}$ thick (a series of these extending to the south-west shore line),	,,	18°–19° W.
101.	Between Martello Tower and Battery, jointing, .	,,	30° E.
102.	Under Martello Tower, jointing, ...	,,	48°–49° E.
103.	,, ,, ,, ,, ...	,,	16°–17° E.
104.	Near south corner of enclosed field, ...	,,	58° E.
105.	North corner ,, ,, ,, ...	,,	51° E.

Dalkey Railway :—

106.	Between the two bridges, east of Sandycove Station, on north side, vertical jointing, . . .	Nm.	7°–8° W.
107.	At bridge, 100 yards west of Glenageary Church, .	,,	18°–23° W.
108.	,, ,, ,, on north side of line, well-marked joint, with slight dip to south, .	,,	23° W.
109.	East of bridge, at Glenageary Church, repeated jointing, slight dip to east, ...	,,	39° E.
110.	,, ,, ,, ,, ,, .	,,	36° E.
111.	,, ,, ,, ,, ,, .	,,	42° E.
112.	40 yards east of bridge, vertical jointing,] . .	,,	48° W.

Dalkey :—

113.	Entrance to old Quarries, Dalkey, north-west side, great face of rock, ...	,,	20°–22° E.
114.	,, south-east side, great face of rock, .	,,	2°–3° E.
115.	,, south-west side, ,, ,, ,, . .	,,	7°–8° W.

Dalkey Quarries :—

116.	East side of eastern quarry, vertical face, . .	,,	10°–12° W.
117.	,, ,, ,, another, vertical face,	,,	21° W.
118.	,, ,, ,, general direction, .	,,	18° W.
119.	Eastern quarry, south-east corner, great vertical face,	,,	18° W.
120.	,, ,, 20 yards from south-west corner, vertical joint, with quartz vein,	,,	18°–19° W.
121.	,, ,, vertical cross jointing, apparently,	,,	58°–59° E.
122.	,, ,, west side, south end, great face, .	,,	12°–13° W.
123.	,, ,, ,, towards middle ,, .	,,	11°–12° W.
124.	,, ,, ,, at north-west end, face,	,,	5° W.
125.	,, ,, cross jointing, at south end, rough and broken, ...	,,	54°–55° E.
126.	Middle lower Quarry, north-east side, vertical face,	,,	21°–22° W.
127.	,, ,, ,, outcrop on ground,	,,	21° W.
128.	,, ,, south-east side, great vertical face, ...	,,	12°–13° W.
129.	,, ,, south-west side, great central rib, under old Telegraph, .	,,	18° W.
130.	,, ,, Eurite vein, on continuation of this, ...	,,	17°–18° W.
131.	,, ,, ,, ,, ,, .	,,	21°–22° W.
132.	,, ,, ,, ,, ,, .	,,	17°–18° W.
133.	,, ,, west side, joint near Eurite vein, dip east, ...	,,	22°–24° W.
134.	,, ,, west side, Eurite vein, dip east,	,,	25°–26° W.
135.	,, ,, ,, joint more to west, with same dip, . .	,,	25°–26° W.
136.	,, ,, ,, great Eurite vein, $0^{m}\cdot30$ thick, dip west, .	,,	21°–22° W.
137.	,, ,, ,, cross jointing, . .	,,	42°–43° E.
138.	,, ,, ,, great vertical face, .	,,	17°–18° W.
139.	,, ,, north-west point, Eurite vein,	,,	26°–27° W.
140.	Upper Quarry, great Eurite vein, $0^{m}\cdot25$ thick, under old Telegraph, ...	,,	26°–27° W.
141.	,, ,, another in same place, . . .	,,	13° 30′–14° W.
142.	,, ,, great Eurite vein, $2^{m}\cdot50$ thick, dipping east, running approximately in direction of Blackrock P. Church,	,,	28° 30′ W.
143.	,, ,, ,, ,, ,, ,, .	,,	30° W.

[illegible] Quarries—continued.

144. [illegible] Quarry, 6–7 yards west, great dyke of felspathic porphyry, . . . N- 44° W.
145. — — quartzite vein, ... — 18° W.
146. — — 10 yards west of this joint, . . . — 21° W.
147. Lower west Quarry, north-west point, joint, . . — 13° E.

Carrickmines:—

148. Joint in granite, 400 yards south of Station, in [illegible] field, ... — 2° W.

The Dingle:—

149. Jointing of rock in, on east side, ... — N-
150. On west side, beside cottage, [illegible] jointing, . . . — 63°–64° W.

Carrickmines:—

151. Lode, north of smoke stack, ... — 57° W.

Scalp:—

152. In wood, on east side, [illegible] slate rock, . . ,, 4° W.
153. Jointing in granite [illegible] side, ... ,, 4° W.

Howth:—

154. Balscadden Bay, [illegible] highly altered slate [illegible] east of bathing-[illegible] . . . . ,, 29° E.
155. — — [illegible] detached rock called [illegible] . . . . ,, 84°–85° W.
156. Puck's Rocks, well-[illegible], ... ,, 6° E.
157. — — apparent [illegible] more easterly rock, — 46°–47° E.
158. — — joint near this, ... 16° E.
159. — — cross jointing, ... 59° W.
160. Knocrown, joint in slate rock, in recess near private house, ..., 5°–6° W.
161. Dung Hill, second hill from west, on west side, opposite plantation, apparent jointing on west side with quartz and Eurite jointing, ... 14° E.
162. .. .. on top of hill, in a mass of Euritic-looking rock jointing, ... 4° W.
163. .. .. 4° W.
164. .. .. N-
165. .. .. north-west extremity of iron ore lode well marked, corresponds with direction of top of Ireland's Eye and west slope of Lambay Island, ..., 40°–44° E.
166. Red Rock, near cottage, in entrance of a well-marked depression, 250 yards west of Candle-house, well marked face of jointing, .. 69°–70° W.
167. .. .. cross jointing, apparently, . . ., 4°–5° E.
168. .. .. to the east of this, in dell, jointing, . ,, 37° E.
169. .. .. this boss of altered slate rock traversed by well-marked vertical joints, . . ., 12°–13° E.
170. ,, ,, ,, .. ,, ,, . ., 12° E.
171. At Carrickbrack House, at bend of road, joint, . ,, 74°–75° E.
172. ,, ,, cross jointing, . . ., 8°–10° W.
173. ,, ,, well-marked jointing here, dip to east, . . . ,, 36°–37° E.

uarries—*continued.*

	Quarry, 6–7 yards west, great dyke of feldspathic porphyry, . .	N–	44° W.
	,, ,, quartzite vein, ...	,,	18° W.
	,, 10 yards west of this joint, . . .	,,	21° W.
	er west Quarry, north-west point, joint, .	,,	13° E.

ines :—

	.. in granite, 400 yards south of Station, in .urze field, ...	,,	2° W.

The Dingle :—

149.	Jointing of rock in, on east side, ...	,,	N–
150.	On west side, beside cottage, cross jointing, . .	,,	63°–64° W.

Carrickmines :—

151.	Lode, north of smoke stack, ...	,,	57° W.

Scalp :—

152.	In wood, on east side, jointing in slate rock, .	,,	4° W.
153.	Jointing in granite face, on east side, ...	,,	4° W.

Howth :—

154.	Balscaddan Bay, quartz vein in highly altered slate rocks, 220 yards east of bathing-place, ...	,,	29° E.
155.	,, ,, south side of detached rock called "The Stag,"	,,	84°–85° W.
156.	Puck's Rocks, well-marked joint in, ...	,,	6° E.
157.	,, ,, apparent dyke in more easterly rock,	,,	46°–47° E.
158.	,, ,, joint near this, ...	,,	16° E.
159.	,, ,, cross jointing, ...	,,	59° W.
160.	Kitestown, joint in slate rock, in recess near private house, ...	,,	5°–6° W.
161.	Dung Hill (second hill from west, on west side, opposite plantation), apparent jointing on west side with quartz and Eurite jointing, ...	,,	14° E.
162.	,, ,, on top of hill, in a mass of Euritic-looking rock jointing, ...	,,	4° W.
163.	,, ,, ,, ,, ,, ,, .	,,	4° W.
164.	,, ,, ,, ,, ,, ,, .	,,	N–
165.	,, ,, north-west extremity of, iron ore lode well marked (corresponds with direction of top of Ireland's Eye and west slope of Lambay Island), ...	,,	40°–44° E.
166.	Red Rock, near cottage, in entrance of a well-marked depression, 250 yards west of Candle-house, well marked face of jointing,	,,	69°–70° W.
167.	,, ,, cross jointing, apparently, ...	,,	4°–5° E.
168.	,, ,, to the east of this, in dell, jointing, .	,,	37° E.
169.	,, ,, this boss of altered slate rock traversed by well-marked vertical joints, . .	,,	12°–13° E.
170.	,, ,, ,, ,, ,, ,, .	,,	12° E.
171.	At Carrickbrack House, at bend of road, joint, .	,,	74°–75° E.
172.	,, ,, cross jointing, . . .	,,	8°–10° W.
173.	,, ,, well-marked jointing here, dip to east, ...	,,	36°–37° E.

Howth—*continued.*

174.	Loughoreen Hills, mass of rock facing plantation, vertical jointing, in Euritic-looking rock, with much quartz and red oxyde of iron, . .	Nm.	5° W.
175.	,, ,, on top of rock, quartz veins, nearly vertical, Euritic-looking mass, ...	,,	67°–68° E.
176.	Cromlech Dell, jointing running across dell, .	,,	72°–73° W.
177.	,, ,, another system of joints, . .	,,	37° E.
178.	,, ,, cliff side in dell, ...	,,	23°–24° E.
179.	,, ,, jointing, cutting off north-west point of Muck Rock (passes over summit of Ireland's Eye and Lambay), ...	,,	37°–38° E.
180.	Sutton, Dolomites at Sutton quay, life-boat station, well-marked vertical jointing, .	,,	36°–37° E.
181.	,, ,, ,, ,, at another point,	,,	41°–42° E.
182.	,, ,, on surface of Dolomite, . .	,,	38°–39° E.
183.	,, ,, cross jointing, ...	,,	1° E.
184.	,, ,, another system of, ...	,,	68°–69° W.
185.	,, ,, ,, ,, . . .	,,	3° W.
186.	,, ,, ,, ,, ...	,,	6°–7° W.
	,, The Dolomite cut off and abutting against decomposed quartzites, 50–60 yards west of Coast-guard Station.		
187.	,, Coast-guard Station, jointing in slate rock, under flag-staff of, ...	,,	21° W.
188.	,, little promontory east of Coast-guard Station (near Bottle Quay), the slate much broken and jointed vertically, . .	,,	60° E.
189.	,, quartz veining, very frequent here, cuts previously mentioned joint nearly vertically,	,,	70°–73° W.
190.	,, vertical joint cutting these, not very marked,	,,	33° E.
191.	,, to the east of last-mentioned point, well-marked, frequent and vertical jointing, .	,,	39° E.
192.	,, ,, further east, ...	,,	28° W.
193.	,, 250 yards west of Martello Tower, great joint in slate rock filled with quartz veins, indistinct in the true slates, . . ,	,,	25°–35° W.
194.	,, about 100 yards west of Martello Tower, well-marked quartzose veins in the slate, dipping at a high angle north-east, .	,,	24° E.
195.	,, frequent and vertical jointing, cutting all these green slates, ...	,,	7° W.
196.	,, Martello Tower, mass of quartzite, on which the tower built, much fissured, west side,	,,	87° W.
197.	,, ,, ,, ,, ,, ,, .	,,	82°–85° W.
198.	South side, Martello Tower, on east side, 12 yards from it, well-marked vertical jointing, .	,,	90° E.
199.	,, ,, ,, cross jointing, well marked and vertical, ...	,,	4°–5° W.
200.	,, cross jointing, well marked, ...	,,	43° E.
201.	,, (forms the little creek just under Tower), .	,,	38°–39° E.
202.	,, 60 yards east of tower cave, joint, . .	,,	15°–18° E.
203.	,, 150–180 yards east of Tower, immense jointing, giving rise to a cave, . .	,,	50° W.

continued.

.		South side, 300–400 yards east of Tower, splendid vertical jointing, ...	Nm.	3°–4° W.
	,,	,, ,, ,, ,, ,, .	,,	2°–3° W.
	,,	,, ,, ,, vertical jointing, cutting shore here less distinctly marked,	,,	21° E.
	,,	,, ,, ,, ,, ,, .	,,	23° E.
	,,	120 yards east of Tower, joint apparently a fault with cave, ...	,,	28° W.
7.	,,	450 yards east of Tower, vertical jointing in red rock, well marked, . . .	,,	8° E.
.	,,	,, ,, ,, ,, jointing,	,,	29° E.
.	,,	500 yards east of Tower, jointing, . .	,,	38° W.
.	,,	,, ,, cave joint on fault, .	,,	27°–28° E.
[illegible]	,,	great joint further east, 1m· wide in places, having caused fall of surface rocks, distant from previous joint about 20–25 yards,	,,	28° E.
214.	,,	about 525 yards east of Tower, cross jointing, dipping east, ...	,,	88° E.
215.	,,	a series of great joints occur here at short intervals, ...	,,	26°–28° E.
216.	,,	another system of jointing, well marked, dipping east, ...	,,	43° E.
217.	,,	east of Drumleck Point, Little Boat Harbour, frequent and well-marked vertical jointing, ...	,,	16° E.
218.	,,	near the Boat Harbour, to the east, occurs a great open joint, cut down to low water, 5 feet broad at bottom, formed by previous jointing with another, ...	,,	3° W.
219.	,,	about 250 yards east from boat-house, jointing in a mass of quartzite, . .	,,	20. E.
219bis.	,,	,, ,, ,, ,, ,, .	,,	18° E.
220.	,,	vertical quartz veins in, ...	,,	82°–85° E.
221.	,,	about 400 yards east from boat-house, frequent and vertical jointing, indenting the coast line, ...	,,	3° W.
222.	,,	250 yards south-west from Tansey House, frequent vertical jointing here, . .	,,	21° E.
223.	,,	about 80 to 100 yards east from this point, great fault dislocating the ground, dip east at 75°–80°, ...	,,	38°–39° E.
224.	,,	crossed by jointing, (accompanied by a band of decomposed trap rock), . .	,,	3°–5° W.
225.	,,	"Sheep-hole" cave and little inlet, the cave apparently on a greenstone dyke, dipping east, ...	,,	36°–38° E.
226.	,,	creek to east of "Sheep-hole," vertical lode or joint on west side of, 0m·50 at ground surface, ...	,,	35°–38° E.
227.	,,	west side of Drumleck Point, at about 50-60 yards east of previous point, well-marked jointing, dipping east, at angle of 60°–70°, ...	,,	39° E.
228.	,,	vertical jointing in quartzite, to the east of this point, ...	,,	11° E.
229.	,,	jointing in this quartzite, ...	,,	17°–18° E.
230.	,,	cross jointing, frequent and vertical, .	,,	7°–8° W.

Howth—*continued.*

South side, east of bathing-place, at point called the "Worn-hole," vertical quartz veins, very distinct with parallel ones,	Nm.	23°–24° E.
,, opposite dwelling-house, joint dipping east,	,,	7°–8° W.
,, about 350 to 400 yards east of bathing-place, great vertical joint, 3 feet broad in an apparently altered rock, greatly weathered,	,,	33°–34° W.
Drumleck Point, east of great fissure in greenstone rock,	,,	5° W.
,, cross jointing,	,,	67°–68° W.
,, Bay, west side of, vertical joint,	,,	47°–48° W.
,, "Broad Strand," immense face of jointing on east side of bay, extending from top to bottom of cliff,	,,	3°–5° W.
,, "Lion's Head," little promontory near the Bailey Light,	,,	39° E.

Ireland's Eye:—

Fault in slate rock, towards south-east point,	,,	87°–88° E.
At south-east point, in black mica slates (Thulla Rocks),	,,	13°–14° E.
On south-east side, just south of first creek, in slate rocks, jointing in,	,,	43°–44° W.
The west side of first creek and east side of the detached rock called "The Stag,"	,,	36°–37° E.
North of Rowan's Rocks, in little creek on east side, cross jointing at the entrance,	,,	73°–74° W.
Jointing running across the mouth of same, nearly vertical,	,,	3°–5 W.
East side, apparent contact of quartzite with dark shales (Samphire Hole),	,,	68°–70° W.
In Samphire Hole,	,,	50°–60° W.
In cave,	,,	50°–56° W.
North-east point, well-marked vertical jointing in quartzite under "Stags,"	,,	75°–76° W.
,, vertical joint frequent and well marked, apparently parallel to axis of gut between "Stags,"	,,	3°–5° W.
Middle of Island, to the north, jointing in boss of white quartzite,	,,	84°–85° W.
300 yards east of Martello Tower, well-marked vertical joint, with slight dip to west in quartzite,	,,	53° E.
,, ,, well-marked cross jointing, running towards Tower,	,,	32°–33° W.
,, well-marked jointing, running towards Skerries,	,,	26°–27° W.
Apparent contact face of quartzites with altered shales, 100 yards north of St. Nessan's Church,	,,	77° W.

Howth:—

Centre of Hill, jointing in slate rock, much broken and weathered,	,,	71° E.
,, ,, ,, ,, ,, ,,	,,	69° E.
,, trench opened on jointing,	,,	38°–40° E.

The foregoing observations having been grouped relativel direction, the mean true direction corresponding to each group ha been taken, and a classification according to frequency of occurren each direction having been made, there resulted the following Tabl

JOINTS AND LINES OF DIRECTION GROUPED AND REDUCED TO T BEARINGS.

Easterly.				Westerly.		
Relative Rank as to Frequency.	Direction.	Number observed.	Total.	Relative Rank as to Frequency.	Direction.	Number observed.
14	1° 55′ E.	6		20	1° 54′ W.	5
11	5° 43′ ,,	9		15	5° 26′ ,,	6
12	10° 19′ ,,	7		9	9° 27′ ,,	10
1	16° 23′ ,,	26		21	14° 17′ ,,	5
4	21° 20′ ,,	13		31	21° 40′ ,,	3
29	25° 50′ ,,	3		2	25° 52′ ,,	19
25	30° 08′ ,,	4		5	29° 11′ ,,	12
18	35° 36′ ,,	5		22	34° 27′ ,,	5
28	48° 30′ ,,	4		6	39° 57′ ,,	12
26	66° 08′ ,,	4		3	43° 51′ ,,	14
33	61° 30′ ,,	1		10	47° 42′ ,,	10
19	72° 35′ ,,	5		8	50° 12′ ,,	11
32	81° 45′ ,,	2		23	59° 24′ ,,	5
30	85° 10′ ,,	3	92	27	65° 15′ ,,	4
				12	70° 39′ ,,	7
				16	78° 15′ ,,	6
				17	84° 55′ ,,	6
				7	89° 45′ ,,	12

Ranging the more important of those directions, relatively to frequency of occurrence, we have the following series :—

1	16° 23′ E.	26 occurrences.	7	89° 46′ W.	12 occurre
2	25° 52′ W.	19 ,,	8	50° 12′ W.	11 ,,
3	43° 51′ W.	14 ,,	9	9° 27′ W.	10 ,,
4	21° 20′ E.	13 ,,	10	47° 42′ W.	10 ,,
5	29° 12′ W.	12 ,,	11	5° 43′ E.	9 ,,
6	39° 59′ W.	12 ,,			

There now remains to be shown the relations which those directions bear to the coast lines on the east side of Ireland; and, furthermore, their relations with the lines of directions corresponding to the principal mountain chains, river valleys, main lines of jointing, and geological lines of boundary of the interior of the country.

Taking the first direction, 16° 23′ E., the mean of twenty-six observed directions (but not necessarily the mean of all the similar directions which might be observed in Ireland), it will be found that this is the direction of the coast line between Carnsore Point and Wicklow Head, as exactly as possible; also the line of direction between Carmel's Point, N. W. Wales, and St. David's Head, S. W. Wales. It also represents the boundary line limiting the granite of Wicklow, on the west side, between Castledermot and Goresbridge, and the general direction of the mountains between Kippure and Achavannagh mountains, as shown on Griffith's general map of Ireland. It represents, therefore, a coast line and a line of mountain direction. It also represents a band, or zone, of parallel joints which must extend over a considerable distance, and over a certain breadth of country. If we examine the extension of this direction on the map of Great Britain, it will be found to pass through the Mull of Galloway, near Cairngarroch Bay, to pass at Ayr, Ben Mac Dun chain, and to come out at Elgin—this direction being that of the north-east coast of Scotland, between Fifeness and Peterhead. The continuation of the line of direction passes through the Shetland Islands, on the western side, parallel to their general or longer axis, and to the geological boundary line of the southern promontory of Mainland Island. If it be further examined, with reference to the Great Circle of which it forms a part, it will be found that its extension traverses the Northern Ocean, parallel to a line joining Bremanger Land (the most westerly point of Norway) with Great Ice Cape (the north-east point of Nova Zembla), at about a distance of 3° 47′ from those two extreme points. It then crosses Siberia from the mouth of the Lena to Okhotsk, where it emerges, making with the coast lines east and west angles of about 70°. It traverses the North Pacific, crosses New Caledonia, passes through New Zealand, from Mount Cook to Dunedin, and finally cuts the west coast of Africa, from Bathurst to Cape Bojador. If we compare the extent of land traversed to that of ocean surface, it will be found that these extents stand to one another somewhat in the ratio of 1 : 15; that is to say, that this Great Circle is one of considerable contraction of the surface towards the Earth's centre, and it will be easily recognised that there are not many other Great Circles of greater contraction. Its importance, physically and geologically, has, therefore, a certain significance, lying, as the line or Great Circle does, on the boundary between the Old and New World.

The second direction, 25° 52′ W., is remarkable from more than one point of view. As a coast direction it only shows itself about Killiney, representing the axis of Dalkey Sound, and the depression between the first and second Hills, or between the Telegraph and

It is well and markedly represented by the Scalp, and e, to the north-east of the Scalp. It is, however, well e Mourne Mountains, as shown by the Survey maps, and nts the north-east coast line of Ireland, between Burial Rathlin Island, coinciding with the coast line between and Long Rock, Co. Down. This joint system is nearly vertical, and in some places very distinct. Its extension is very remarkable, passing through Iceland, near Hecla, to a direction which is that of the north-west coast of the or bay called Hunaflood, or Bear Cub Flood, and which is of many of the inlets between Portland and Ingolfshead, th-east coast line. It crosses North Western America, from n, on the north side, to Mount Fairweather, on the Pacific passes between Honolulu and Woahoo (Sandwich Islands); New Zealand to the east, and nearly parallel to the axes of the : through Enderby's Land; cuts the south coast of Africa at a Bay; traverses Africa, parallel to a line joining the Cape of d Hope with Cape Lopez Gonsalvez; cuts the river Congo, at ey's Pool, that is, about 0° 30′ east of the Kalulu Falls; passes at rs, and, crossing the Mediterranean, enters Spain at Tarragona; es the Pyrenees; passes at Rochelle, St. Malo, Startpoint, Bideford and the south-west promontory of Wales. If the line between hy Head, in the south, and Cape Wrath, in the north, be taken as about the longest axis of Great Britain, it will be seen that the direction of this axis is about that of the direction under consideration: it will indeed be found to represent sufficiently closely the line joining the coast of Yarmouth with the coast line at Peterhead. It may, therefore, be considered as having a representative character.

The direction 43° 51′ W. is represented by only short stretches of the eastern Irish coast line, such as the south side of the Bay of Dublin, and the line between Skerries and Balbriggan. It also corresponds with portions of the Trap dykes north-east of Lough Erne, with the longer axis of this lough, and with the direction of the Trap dyke marked as running between Maghery Bay and Trawenagh Bay, Co. Donegal. Outside Ireland, the corresponding Great Circle passes through a number of very interesting points; but it may be sufficient to remark, that passing through Monmouthshire, it represents very closely many of the numerous faults characterising the South Wales coal-field, as may be seen by the Geological Survey of the district.

The direction 21° 20′ E. is represented by parts of the south-east coast of Ireland, the outline of which it goes to form, in combination with the direction 16° 23′ E. It also represents the direction of the Downpatrick coast, and the coast line extending between Corsewell Point and Ayr, in Scotland. Furthermore, it may be taken as representing in direction the longer axis of Ireland—that running from Mizen Head to Malin Head, and thus passing through Lough Fergus, on the Shannon, according to its longer axis, and defining the western limit of the middle carboniferous limestone. As a Great Circle direc-

tion, it has nearly the same interest, and passes through the same countries nearly, as the direction 16° 23′.

The only other directions to which attention may be more particularly called are the directions 89° 45′ W.; 9° 27′ W.; and 5° 45′ E.

The direction 89° 45′ W. is represented at Dublin by the jointing in the granite rocks which occur at Blackrock, and which are the most northerly outcrops of the rock. Its continuation across Ireland, from that point, brings it out at Galway, and there corresponding with certain portions of the granite coast line. It represents the line of least elevation crossing Ireland from east to west, and is roughly represented farther south by the line which would pass from Carnsore Point to the Great Blasket Islands. It may be taken as the direction of the axis of the Liffey valley.

The direction 9° 27′ W. represents fairly the coast line between Wicklow Head and Dunany Point, in the Co. Louth; and its continuation passes through the Mourne Mountains, along a portion of the west side of Lough Neagh, and comes out on the coast of Antrim, near the promontory of Portrush. The angle of 40° with this gives a direction which corresponds very closely with that of the Caledonian canal, while the direction 70° with the canal takes in Fifeness, Bamborough Head, and the coast line between Foulness and Yarmouth.

This same direction, ...	9° 27′ W.
gives with the direction, ...	30° 08′ E.
(so remarkable at Ireland's Eye), an intersection of	39° 35′

Lastly, the direction 5° 43′ E. represents the portion of the coast line between Baldoyle and Rush; but more particularly represents the direction of the Great Circle which I had traced, *à priori*, on the globe as the "*West Coast of Portugal*," and which is represented by well-marked faulting in three or four places, by hill direction, and by the east side of Rathlin Island.

As regards the eastern coast of Ireland, it may be fairly advanced that it is represented by directions which correspond to lines of jointing observable, in greater or lesser number, about the Bay of Dublin, and which are as follows:—

From Carnsore Point to Wicklow Head, . . .	16° 25′ E.
,, Wicklow Head to Clogher Head, ...	9° 27′ W.
,, Bellagan Point, Carlingford Lough, to John's Point, Dundrum Bay, . .	48° 30′ E.
,, Donaghadee to Bruce's Castle, Rathlin Is.,	29° 11′ W.

The three last directions are not the more frequently occurring in the Bay of Dublin, but do occur. It should be noticed that the direction 48° 30′ E. is almost exactly that of the line of porphyritic rocks so markedly characterising the geology of the county Wexford.

; the correlation of the directions enumerated, in accord-
e theory laid down in my memoir on that subject, I
rom one or other of the Great Circles which are found to
and. Now, as the number of coast-line Great Circles
. the globe has not been worked out so as to bring all
1 coast lines available into the system, I can only for the
...w the connexion existing between those Great Circles
.. far, I have found to traverse Ireland, and the principal
lirection observed by me about the Bay of Dublin.
. three Great Circles traversing Ireland, on the eastern side, so
...ed, are—

The St. Lawrence Great Circle (No. 12), cuts meridian 10° W. in Lat. 52° 45′ N., at angle of 73° 45′ E. of S.

,, Caucasus Mts. Great Circle (No. 23), cuts meridian 10° W. in Lat. 52° 30′ N., at angle of 81° 20′ W. of S.

,, W. Coast of Portugal Great Circle (No. 15), cuts No. 23 G. C. in Long. 7° 2½′ W., at angle of 78° S. of W.

The Wexford coast line (16° 23′ E.) makes with the Caucasus Mountains Great Circle an angle of 70° very nearly. Taking the intersection of this Great Circle with the meridian 6° W.

at 84° E. of south, this represents	96° W. of N.
Now, the second principal direction occurring about the Bay of Dublin has been shown to be . . .	25° 52′ W.
The difference therefore is	70° 08′,

a sufficiently close approximation.

But the direction 25° 52′ W., and the direction 16° 23′ E. intersect at angle of	42° 15′.

As the angles of which these are means vary by more than 3°, it is evident that for certain values, such as 37° E. and 3° W. (magnetic), the angle of intersection would just be 40°.

The eastern boundary line of the granite mass of the Co. Wicklow is fairly represented by the direction 30° 08′ E. Now this direction makes with the St. Lawrence Great Circle, where it passes to the north of Tramore Bay, an angle of 80° very nearly.

Taking it at	30° 08′ E.,
it intersects, in the neighbourhood of Killiney Bay, the coast line lying between Wicklow Head and Clough Head, of which the mean direction is taken at	9° 27′ W.
The angle of intersection is therefore	39° 35′,

which, for the reason previously cited, is a fair approximation to the theoretical angle of 40°. (This direction of 30° 08′ E. is very remarkable at Ireland's Eye.)

Nearly similar intervals occur between the directions 89° 45′ W., 50° 12′ W., and 9° 27′ W.: thus we have 39° 33′, and 40° 45′ as these intervals; while the mean of the four values, 42° 15′, 39° 35′, 39° 33′, and 40° 45′, is 40° 32′, which sufficiently represents the angular relation adopted by the theory.

It would be easy to multiply the number of cases of intersections at angles closely approximating to the values 80°, 70°, 40°; but there is a simpler and more direct proof of the correspondence of the actual lines with the theoretical: it is, that the Great Circles already mentioned correspond in a marked manner with actual lines of direction, such as main jointing, river valleys, and mountain ridges, and that from them may be derived most, if not all, the principal coast line directions. If it were possible to have the main lines of jointing carefully laid down for the whole of Ireland, it would be still more easy to multiply cases of intersection at the angles indicated, since it is fair to presume that the conclusions to be drawn from their correlation with the coast lines, and the Great Circles already cited, would not be less in accordance with the theory than those arrived at for the neighbourhood of the Bay of Dublin.

L.—On the Correlation of the Lines of Faulting of the Palamow Coal-Field District, Northern India, with the neighbouring Coast Lines. By J. P. O'Reilly, C.E., Professor of Mining and Mineralogy, Royal College of Science, Ireland.

[Read, April 12, 1880.]

Having received from Mr. Valentine Ball, of the Geological Survey of India, copies of his memoirs on the coal-fields of the Palamow district, Bengal Presidency, to which are annexed detailed maps illustrative of the geological characteristics of this district, I was led to examine the very remarkable lines of faulting which these maps present, relatively to their angular correlation with the coast line Great Circles passing through or near this district.

I considered this an excellent occasion of applying the theory of correlation of lines of direction submitted to the Academy in June, 1879, since I could have but little previous knowledge of the district on the one hand; and, on the other, the length and straightness of the lines of faulting are so remarkable, that their concordance with the theory should, so far, be a strong proof in its favour. The maps are to a scale of one inch to the mile, and therefore sufficiently large to show details with clearness.

The only great circle, of those originally traced by me on the globe, which I find to intersect the district, is that which I call the *Beluchistan East and West Coast-line Great Circle*, or, as I shall call it, the *Beluchistan Coast-line*. On the globe it cuts the meridian of 90° E. in latitude 23° 45′ N., at an angle of about 84° 31′ W. of N. This I have transferred to the maps, or rather parallels to this direction. I have further traced thereon parallels to a line of direction making, with the eastern Ghats coast-line of India great circle, an angle of 40°. Its direction differs from that of the Beluchistan coast line great circle by about 4°, that is, it would cut the meridian 90° E. at about 88°–89° W. of N. For convenience I shall term it "*The 88° W. of N. Line.*" I might have introduced other great circles or parallels to them, but the most direct proof and the simplest is the best, and I therefore confine my examination to the angular relations between the lines of faulting presented by the maps and these two principal lines of direction.

There are two 1-inch scale maps, the one of the Hutar coal-field, the other of the Auninga coal-field.

Taking the first, on which I have traced parallels to the Beluchistan coast great circle, and to the 88° W. of N. line, I find the following angular relation for the lines of faulting, and other principal lines:—

I.—A line drawn at 70° with the Beluchistan coast-line great circle, and passing through Murwaie Kullan, defines the eastern side of the coal-field.

II.—A line drawn at 40° with this gives very distinctly the northern boundary of the coal-field, over an extent of sixteen miles.

III.—A line drawn at 40° with the Beluchistan coast-line great circle (from W. to E.), and passing near Hurtah, in the north of the map, gives the direction of the mountain chain passing near this point.

IV.—The line at 30° with this, and consequently running nearly due east and west, gives the direction of certain of the sets of joints indicated in the southern part of the map, as also the southern boundary of the Mahadeva Rocks, marked Bitwa.

Taking now the second direction, that at 40°, with the eastern coast-line great circle, or as I termed it, the 88° W. of N. line:—

V.—A parallel to it gives a well-marked direction of jointing passing near Tataha, and running nearly east and west. The coincidence over the principal portion is distinct.

VI.—In the north of the coal-field this direction corresponds with that of certain of the Trap dykes marked thereat.

The line of jointing running N. N.W. and S. S. E., by the Munga Hills, I do not see how to correlate distinctly with either of the above-mentioned principal directions, that is to say, to within four or five degrees.

VII.—Taking the map of the Aurunga coal-field, and tracing on it the two directions already employed (that is, the Beluchistan coast-line great circle, and the 88° W. of N. line), there is immediately obtained the direction of the very marked jointing which runs from Rukhaut, in the south-east, to Obur, in the east centre, *an extent of eleven miles*. This line is slightly inflected, and presents, as traced on the map, two directions—the one concords with the line at 40° with the Beluchistan coast great circle, and the other with the line making the same angle with the direction 88° W. of N.

VIII.—The two main lines of direction (Beluchistan coast and 88° W. of N.) give very distinctly parts of the east and west line of jointing, which runs from Rampur to Tuppah.

IX.—They also define the system of jointing with hot springs, which runs east and west between Joreesuklowa and Punkra, towards the northern limit of the coal-field, the length between the extreme points being nine miles.

X.—The system of jointing running N.W. by W., from Tuppah to Putkee (eight miles), can be easily correlated with the two main lines of direction by the intermediary of the angle of 80°.

XI. and XII.—A line drawn at 70° with the Beluchistan coast line great circle gives the direction of the jointing or bedding of the patch of limestone occurring in the north-east of the field; while the well-marked joint or fault crossing the direction of these limestones, from E.N.E. to W.S.W., makes with the direction of the jointing which runs from Putkee to Tuppah an angle of 40°.

The jointing which runs east and west, north of Tuppah, and its parallel about one mile to the south of it, do not give any direct and precise angular relation with either of the two principal directions already mentioned.

A few subordinate directions can also be correlated with those directions, as shown on the map, but it is not necessary to insist on them.

It will thus be seen, that at least twelve different lines of direction of jointing can be distinctly correlated with the two principal lines employed—viz., the Beluchistan coast line, and the line which makes 40° with the east coast of India great circle—by simple angular relations.

There are a few main joints which are not so correlated, because the angular relations which might be established would show differences of 4° to 5° with the theoretical values admitted: this so far goes to show how distinctly the twelve other lines do concord with the theoretical directions, and, therefore, so far go to support the general theory of correlation submitted by me to the Royal Irish Academy.

LI.—PRELIMINARY REPORT ON SOME NEW ORGANIC NITROPRUSSIDES. By EDMUND W. DAVY, A. M., M. D., M. R. I. A., Professor of Forensic Medicine, Royal College of Surgeons, Ireland, etc.

[Read, June 14, 1880.]

THE Nitroprussides, or Nitroferricyanides, a class of salts obtained by the action of nitric acid on the soluble ferro- or ferricyanides, which were first studied by Dr. Lyon Playfair, have not received on the part of chemists the attention that might have been expected from the interesting properties possessed by those compounds; and though it is now over thirty years since they were first investigated, still comparatively little has been added to our knowledge of these salts beyond what was ascertained by their original investigator, who described in his classic researches, very fully, the principal characters of nitroprussic acid, and of some of its more important metallic salts.

As the organic combinations of that acid have received scarcely any attention, and as I thought a field for investigation was therefore open in this direction, I applied last year for a small sum out of the Parliamentary grant (given to the Academy for the encouragement of scientific research) to aid me in the necessary expenses attendant on such an inquiry.

The vegetable alkaloids being as a class the most interesting and important organic bases that we are acquainted with, I naturally directed my attention to them in the first place; and I would now beg leave to lay before the Academy, as a preliminary report on the organic nitroprussides, the facts I have already ascertained respecting the combinations of nitroprussic acid with some of the more important of those substances, which, I should hope, may prove to be of some practical value, as adding to the distinctive characters of the vegetable alkaloids, and thus furnishing some additional means for the detection and separation of those bases under different circumstances. I shall commence by making a few remarks on these salts in general, and afterwards describe some of the more important of them separately in detail. I have ascertained that nitroprussic acid, the composition of which is represented by the formula $H_2(NO)FeCy_5$, is capable of forming compounds with the different vegetable alkaloids or bases. These combinations, for the most part, I find to be very sparingly soluble in water; and, when they are such, they may be readily obtained by treating any of their soluble salts with a solution of sodium nitroprusside, when the alkaloid will be precipitated in union with nitroprussic acid, producing sometimes a very characteristic deposit. On being so formed, the salt will in some cases, as in those of strychnine and brucine, exhibit itself from the first as a more or less crystalline precipitate; but in many instances, if the precipitated nitroprusside is examined under the microscope, it will be found to be

at first amorphous, or in the form of minute oil-like globules, which latter, on subsiding or on agitation, adhere to the sides and bottom of the vessel containing the mixture, forming a sticky resinous-looking deposit, or the particles agglutinate together into little lumps or masses of a similar character. But these deposits, on standing for a variable period, assume for the most part a more or less crystalline condition. In some cases, however, as for example in that of veratrine and cinchonidine, there appeared to be no disposition on the part of the salts to acquire a crystalline form, even after the lapse of a considerable time.

In the preparation of those nitroprussides of the alkaloids, which, owing to their slight solubility in water, may be obtained by precipitation, as already stated, using any of their soluble salts, still it will be found better in most cases to employ the alkaloid in the form of the sulphate; for this reason, that in the after-washing of the precipitated nitroprusside, to free it from the sodium salts with which it is associated, where the sulphate is used we can easily ascertain whether this has or has not been completely effected, by testing for sulphuric acid with a barium salt, a small quantity of the filtrate (the water used in washing the precipitate); and when such fails to produce any turbidity, it may be considered to be sufficiently washed and all the sodium sulphate with which it was mixed removed. But should the acetate, nitrate, or chloride have been employed, it will not be so easy to ascertain this point. As regards the employment of a chloride of the alkaloid in this case, I may observe that, as more or less of the nitroprusside of the alkaloid is always dissolved during the washing process, its presence in the filtrate interferes with the use of a silver salt for the detection of the alkaline chloride formed along with the nitroprusside when the chloride of the alkaloid was the salt employed.

Some of the alkaloids, as those of morphine and nicotine, as they form very soluble salts with nitroprussic acid, their nitroprussides cannot be obtained by precipitation, as in the case of the former alkaloids; but they can be easily made, either by directly dissolving the alkaloids in nitroprussic acid, or by treating solutions of their chlorides with silver nitroprusside, or their sulphates with a solution of barium nitroprusside, when, in the first case, the insoluble silver chloride, and in the second that of barium sulphate, is formed, either of which can be easily separated by filtration from the soluble alkaloid nitroprusside produced; which on subsequent evaporation, if the salt is crystallisable, can be obtained in a crystalline form. But as it is difficult to know the exact quantity of the barium salt which should be added to decompose completely the sulphate of the alkaloid, the use of the silver nitroprusside, with the alkaloid in the form of a chloride, is to be preferred; as owing to its being an insoluble salt, if it be added in excess it remains without contaminating the nitroprusside of the alkaloid: indeed it is better, as a general rule, that it should be so added, to ensure the complete decomposition of the chloride of the alkaloid, and such excess will be entirely removed during the filtering of the mixture, to separate the insoluble silver chloride formed in the process.

ave ascertained that nitroprussic acid forms (as might have been ed from its being a bibasic acid) two classes of salts with the ds, viz., neutral and acid salts. In the first there exist two les of the base and one of the acid, and in the second one mole- each.

iave also observed that some of the alkaloids—as, for example, ne, strychnine, and brucine—seem to be capable of forming eutral salts, whereas others—as those of quinine, cinchonine, cotine—form both neutral and acid salts, in combining with ussic acid. I have noticed also that where the alkaloids form o classes of salts, that in some cases the neutral salt is the most crystallizable, and the acid one much less so, and *vice versâ;* ie quinine neutral salt crystallizes with great facility, whereas id salt does so with difficulty; on the other hand, the nicotine ılt readily assumes the crystalline form, whereas the neutral pears to be non-crystallizable.

ascertaining the composition of those nitroprussides which I iscovered, some of which I shall presently describe, the mode I d was to dissolve a given weight of the thoroughly dried salt in which, in the case of the more sparingly soluble salts, it was ary to be hot, or even boiling, for this purpose; and then, by the n of a solution of silver nitrate, to precipitate their nitroprussic ı the form of the insoluble nitroprusside of that metal, and from ıount of that salt so obtained to calculate the quantity of nitro- e acid which had been combined with the alkaloid.

to the water of crystallisation given in the case of some of the lline salts, its amount was determined in the following manner: itroprusside from which the moisture had been as far as possible ed by filtering or blotting-paper, and afterwards by exposing the the air at the ordinary temperature, till it appeared to be quite given quantity of it was taken and heated in a water-bath till eight remained constant, when the loss thus sustained was led as water of crystallization; but as it was difficult to ascertain ıer the salt in the first instance had been quite freed from nical moisture, or had not lost some of its water of crystalliza- y the exposure to the air (as it is well known many salts will do so treated), the amounts of such water, given in the formulæ of of the salts to be described, represent the quantities that agree closely with the results obtained by treating the salts in the er just stated; but, for the reasons mentioned, those results will e to be confirmed by further research, before they can be taken resenting the true amounts of water necessary for the crystalli- of those salts.

nay here further add, that the mode I adopted to determine the e of solubility of the different salts in water, at its ordinary tem- ıre, and at its boiling point, was to saturate water at those tem- ires with the salt, and then taking a given bulk of the solution— eight of which, of water alone, at such temperatures was known

—to evaporate it to dryness, and ascertain the weight of the residue or of the salt that had been dissolved in the given amount of water; and in order to obtain a saturated solution of the salt at the ordinary temperature (which in some cases, owing to the very slight solubility of the salt in cold water, would not be easily effected), the usual mode I adopted was to dissolve the salt in hot, or in boiling water, and to leave it to cool and stand for about twenty-four hours, so that the excess of salt dissolved by heat might re-crystallize out of the solution, which, after filtration to separate the crystals, the necessary quantity of it was taken, evaporated to dryness, and the weight of the residue determined.

I shall now proceed to describe the characters of the nitroprussides of some of the more important alkaloids. I shall commence with those which, owing to their sparing solubility in water, may be prepared by precipitation.

Strychnine Nitroprusside.

The first I shall speak of is the strychnine salt, as this is the * only organic nitroprusside, as far as I was able to ascertain, which has received some very slight attention, and concerning which some conflicting statements have appeared. I believe that Mr. John Horsley, of Cheltenham, was the first to point out that sodium nitroprusside formed a crystalline precipitate with strychnine salts, and finding that where it had been added to a mixture of that alkaloid and strong sulphuric acid, the characteristic purple reaction (which is developed by strychnine, when it is acted on by different oxidizing agents under those circumstances) was produced, he proposed it, the sodium nitroprusside, as a more delicate reagent than potassium bichromate for that purpose. But it was subsequently shown by Rogers and Neubauer that this reaction which Horsley observed was due to the nitroprusside he employed containing potassium ferricyanide, known in commerce as the red prussiate of potash—a salt which, several years ago, I myself proposed to be used in conjunction with strong sulphuric acid, as a test for strychnine; and which, according to my experiments, possesses some advantages for that purpose over the potassium bichromate, the salt which is usually employed in the detection of that alkaloid. And I mention this circumstance, as in several chemical works where my name has been quoted in connexion with this test, an error has been made in putting the ferro- instead of the ferricyanide of potassium, as the salt to be employed; for the former, which is well known under the name of the yellow prussiate of potash, has no

* Since my investigations were made, I have ascertained that Mr. Horsley, several years ago, proposed sodium nitroprusside as a test for certain alkaloids, and pointed out that when it was added to solutions of brucine, and to those of morphine, and the mixtures examined under the microscope, that characteristic crystals were produced, as well as in the case of strychnine, to which he had previously directed attention. See *The Chemical News*, vol. v. p. 355.

power whatever of developing the characteristic reaction of strychnine under the circumstances stated. But to return to the sodium nitroprusside; my experiments on that salt fully confirm the statement of those two chemists already mentioned, as to its incapability of developing the purple reaction when added to a mixture of strychnine and sulphuric acid.

I shall now describe the reaction of sodium nitroprusside on a soluble salt of strychnine, and point out some of the properties of the resulting nitroprusside of that alkaloid. When a solution of the former salt is added to one of the latter, there will be immediately formed a dull reddish-white precipitate, which, on being examined under the microscope, will be found to be in great part of a crystalline character, consisting of very fine prismatic crystals. On heating the mixture, the precipitate will dissolve; and on cooling, it will reappear in a lighter and more completely crystalline form, the crystals being arranged in a peculiar brush or fan-shaped manner, or radiating from a point in all directions. Some of this salt which had been precipitated by a solution of sodium nitroprusside, and was washed and dried in the way already described, was taken and heated in the water-bath till its weight remained constant, and the loss sustained by a given quantity was noted. The thoroughly-dried salt was then dissolved in water, and precipitated by a solution of silver nitrate, and the silver nitroprusside so formed ascertained. From these two results—viz., the amount of water lost by drying, and of silver nitroprusside obtained—agreeing most closely with the amounts which should by calculation be furnished by a salt having the formula $(C_{21}H_{22}N_2O_2)^2 . H_2(NO)FeCy_5 + 3H_2O$, where two molecules of the base are combined with one of the acid, plus three atoms or molecules of water of crystallization, there can therefore be no doubt that this formula expresses the composition of the salt, at least as regards the relative proportions of the base and acid. As to the water of crystallization, there is not the same certainty, for this salt readily loses such water by exposure to the air at the ordinary temperature, and consequently it is difficult to remove the moisture without its losing at the same time more or less of the water necessary for its crystallization. Its composition shows that it is a neutral salt, and test-papers indicate the neutrality of its solutions. As to its solubility in water, I found by the means already described that it required about 847 times its weight of cold, and very nearly 66 times its weight of boiling, water for its solution.

It dissolves but slowly and in comparatively small proportion in rectified spirit, either hot or cold, and is only very slightly soluble in chloroform, and still less so in ether, and does not appear to be dissolvable by benzole.

I may observe, as regards the crystallization of this salt, that, though it usually assumes one or other of the forms already described, yet, when it very slowly crystallizes from its aqueous, or more particularly alcoholic solutions, it presents itself, at least in part, under the form

remaining some time longer, became somewhat opaque, and presented a more or less crystalline appearance, which, when examined under the microscope, was found to consist of masses of minute, flattened, oblique prismatic crystals, the forms of which, however, were very different from those of the neutral salt. Some of this nitroprusside, which had assumed the crystalline condition, was washed with a little distilled water, and dried, and the amount of silver nitroprusside which a given weight would furnish ascertained. This was found to correspond almost exactly with the quantity of silver nitroprusside which a salt of the following composition should yield:—$C_{20}H_{24}N_2O_2.H_2(NO)FeCy_5$. It has an acid reaction, and is much more soluble in water than the neutral salt, requiring only about 107 times its weight at the ordinary temperature for its solution, and when so dissolved it gives to the water a reddish-brown colour. It also readily dissolves in rectified spirit, especially on the application of heat. In its composition and properties it is, therefore, a perfectly analogous salt to the quinine acid sulphate. This salt, like the neutral one, on exposure to the air, loses more or less of its water of crystallization.

Cinchonine Nitroprussides.

Cinchonine, like quinine, forms two salts with nitroprussic acid. The neutral one was obtained from cinchonine neutral sulphate, as in the case of the quinine salt, only that in this instance, owing to its greater solubility, a cold saturated solution was employed instead of a hot one. On adding sodium nitroprusside to such a solution of cinchonine, an immediate reddish-white precipitate was formed, which, when examined under the microscope, presented the appearance of minute oil-like globules: these, on agitation, agglutinated into lumps, which stuck to the sides and bottom of the glass in a resinous form, and acquired a darker reddish colour. These masses, on standing till the next day, became crystalline, and small reddish-brown crystals, which were peculiar compound modifications of the cube and octahedron, were found floating on the surface of the liquid and adhering to the sides of the glass containing the mixture. This salt, after draining and washing with a little distilled water, was dried, and the amount of silver nitroprusside which a given quantity would yield ascertained: this was found to agree very closely with that which should be furnished by a salt having the following formula:—$(C_{20}H_{24}N_2O)^2.H_2(NO)FeCy_5$. It is therefore a neutral salt, agreeing in its constitution with the corresponding quinine salt. This salt is soluble in about 192 times its weight of cold, and in about 35 times its weight of boiling, water, and it readily dissolves even in cold rectified spirit. When this neutral salt was dissolved in nitroprussic acid it yielded an acid crystallizable salt, which, no doubt, has the composition of the corresponding quinine acid salt.

Quinidine and Cinchonidine Nitroprussides.

uidine and cinchonidine, two bases which are isomeric or of e percentage composition with quinine and cinchonine (and are l from quinidine—a resinous matter produced in the prepara- ſuinine), form, with nitroprussic acid, as might be expected, and acid salts corresponding with those of quinine and cincho- The quinidine neutral salt is thrown down from the first in ırt as a crystalline precipitate, when a solution of the neutral : of that base is treated with one of sodium nitroprusside. Its are prismatic, and of a very light brown colour. This salt ; about 105 times its weight of cold, and about 50 times of water for its solution; and it is readily soluble in rectified Its solutions are neutral, and there can be no doubt that its .tion is similar to the quinine neutral salt where two molecules ase are united with one of the acid.

cinchonidine neutral salt, which is obtained by the same from the neutral sulphate of that base, is precipitated in the minute oil-like globules, which on subsiding adhere together, g a sticky, more or less transparent, brown deposit, which exhi- disposition to crystallise even after standing for a considerable This, on exposure to the air, hardens, becoming at the same ery brittle and resinous in its appearance. This nitroprusside s about 217 times its weight of cold, and about 21 times of , water for its solution, and it dissolves readily in rectified This salt being neutral in its reaction, there can be no doubt ts constitution is similar to the corresponding cinchonine salt, two molecules of the base are combined with one of the acid. pparent absence of any disposition on the part of this nitroprus- o assume a crystalline condition, affords a distinctive character en this and the corresponding cinchonine salt; for though the lat- precipitated at first like the former, in minute oil-like globules, orms an apparently similar sticky, transparent, brownish deposit, on standing for a variable period of some hours, it becomes highly illine, furnishing very characteristic crystals, as already stated, of which may sometimes be seen floating on the surface of the natant liquid, or adhering to the sides of the vessel in which it is ined. This salt, as well as the neutral quinidine nitroprusside, ves readily in nitroprussic acid, and they both thus form crystal- le acid salts similar to those in the case of quinine and cinchonine; heir further properties I have not yet been able to determine.

Veratrine Nitroprusside.

'eratrine, the active principle of the white hellebore, which is a powerful poison, forms with nitroprussic acid a neutral salt, h may be readily obtained by precipitating its sulphate with m nitroprusside, when it presents itself as a cream-coloured or

almost white precipitate, which is amorphous, and its particles did not agglutinate together like some of the other nitroprussides, which do not assume a crystalline form when so precipitated. It was very slow in subsiding, though it was easily filtered and washed, the filtrate from the first passing through clear: after washing, till it gave scarcely a trace of sulphuric acid, it was dried and examined. In this state it is almost white, and differs little in its appearance from veratrine itself. It is sparingly soluble in both cold and hot water, requiring about 416 times its weight of water at the ordinary temperature, and about 215 at the boiling point, for its solution. This nitroprusside, unlike most of those of the other alkaloids, does not appear to have any disposition to form a crystalline salt, even after long standing. I have not yet been able to ascertain the proportion of base and of acid that it contains; but there can be little doubt that it consists of two molecules of the base combined with one of the acid, as in the case of the neutral salts of the other alkaloids. It is very soluble in rectified spirit, both cold and hot; and in ether it dissolves to a considerable extent, whilst in chloroform its solubility is much less.

From the experiments I made, it does not appear that veratrine is capable of forming an acid salt with nitroprussic acid.

Morphine Nitroprusside.

I shall now describe a few of the nitroprussides of the alkaloids which form very soluble salts, and therefore cannot be obtained by precipitation, as those already noticed.

The very important alkaloid morphine, the chief active principle of opium, forms a readily crystallizable neutral salt with nitroprussic acid. It was obtained by simply dissolving, with the assistance of a gentle heat, morphine[1] in nitroprussic acid, till a perfectly neutral solution was obtained. This, which was of a reddish-brown colour, being filtered, and the filtrate somewhat concentrated by evaporation on the water-bath, began to furnish prismatic crystals; and in order to obtain these of larger size and more perfect form, the solution was

[1] The nitroprussic acid used in forming this and other salts was easily prepared by digesting for some days, with occasional agitation, silver nitroprusside in diluted hydrochloric acid, contained in a well-stopped bottle; when the nitroprussic acid and silver chloride are formed by double decomposition, and the former may be separated from the latter by filtering the mixture. In preparing thus this acid, it is necessary to employ an excess of silver nitroprusside to ensure the complete removal of the hydrochloric acid employed. That such is the case may be ascertained by collecting some of the silver chloride, and this being well washed on a filter with distilled water till the filtrate becomes colourless; if then, after the addition of a few drops of diluted hydrochloric acid to the chloride, the water used in washing it again acquires a reddish colour, it is a proof that there was some silver nitroprusside in excess over that necessary to remove the whole of the hydrochloric acid. Indeed, if the silver chloride formed, after being well washed, has a reddish colour, it indicates the same fact.

then placed under a bell-glass along with a vessel of sulphuric acid, and the air exhausted, by which the further evaporation was readily effected, and when the liquid portion was thus nearly all removed, the crystals were drained, placed on filtering paper, and afterwards exposed to the air for some hours; and when they appeared to be thoroughly dried, the salt was taken for examination. The crystals so prepared were of a reddish-brown colour, and their form that of four-sided prisms, some of which terminated in wedge-shaped ends, but most of them abruptly, as if broken across. A given quantity of the salt was then taken, and heated in the water-bath till its weight became constant: by this treatment the crystals became more or less opaque and friable, so that they were easily reduced to powder, though they retained their external form. I found that the amount of water lost in this way, and the quantity of silver nitroprusside yielded by a given weight of the thoroughly-dried salt, agreed most closely with the quantities of water and of silver nitroprusside which should be furnished by calculation, from a salt of morphine having the formula $(C_{17}H_{19}NO_3)^2$, $H_2(NO)FeCy_5 + H_2O$, where two molecules of the base were combined with one of the acid, plus one atom of water of crystallization. It is consequently a neutral salt in its constitution, and its solutions also indicate its neutrality. The salt appears to undergo no change by exposure to the air, its crystals having retained their form and appearance after long exposure to its action. This nitroprusside dissolves slowly in cold water, but readily in hot; and, from an experiment I made, I ascertained that it required about 112 times its weight of the former for its solution. It dissolves slowly in rectified spirit, especially at the ordinary temperature; and is only very slightly soluble in ether and in chloroform. Before leaving this salt I should observe that it may also be readily obtained by treating a solution of morphine chloride with an excess of silver nitroprusside, when the morphine nitroprusside and the silver chloride will be produced, and the former, which remains in solution, is easily removed from the latter, as well as from the excess of silver nitroprusside that may be present, by filtration.

I may further add that, from some experiments I made, it does not appear that nitroprussic acid is capable of forming an acid salt with morphine.

Nicotine Nitroprussides.

Nicotine (the active principle of tobacco, which is one of the most deadly of our poisons, and, like prussic acid, will destroy life with great rapidity when taken even in very small doses) is capable, I find, of forming two salts with nitroprussic acid, viz., a neutral and an acid one. As the neutral salt does not appear to be crystallizable, whilst the acid one is readily so, the latter possesses the most interest, and consequently was the one I chiefly studied.

It may be easily obtained by adding to an aqueous solution of nicotine nitroprussic acid till the mixture has a strong acid reaction

and the odour of nicotine almost disappears; this solution on evaporation will furnish long prismatic, reddish-brown crystals, the prevailing forms of which are six-sided prisms with truncated ends. These crystals are permanent in the air—at least they appeared to undergo no change by exposure to its influence for a considerable time. This salt is readily soluble in both cold and hot water, and of the former it requires only about 17 times its weight for its solution, and when thus fully saturated with the salt the water acquires a deep reddish-brown colour. It is also soluble in rectified spirit, though rather sparingly so, at the ordinary temperature; but on the application of heat it dissolves in it readily and in considerable quantity, giving to the solution a dark reddish-brown colour, very similar in its appearance to the saturated aqueous solution, and which on cooling yields a considerable proportion of the salt in the crystalline form, and consequently spirit may with advantage be employed in its preparation and purification. It is very slightly soluble in ether, and is almost insoluble in chloroform.

A given weight of the salt, which had been dried by means of blotting-paper and by subsequent exposure to the air, was heated in the water-bath till it ceased to vary in weight, when the crystals acquired a dull appearance from the loss of their water of crystallization; and the amount of such loss, and the quantity of silver nitroprusside that the dried salt yielded, agreed very closely with the quantities which should be furnished by a salt having the formula $C_{10}H_{14}N_2,\ H_2(NO)FeCy_5 + 2H_2O$, where one molecule of nicotine was combined with one of nitroprussic acid, plus two atoms of water of crystallization. It is therefore by its constitution an acid salt, and its solutions possess a strong acid reaction, and the salt itself has no odour of nicotine.

I may further observe that in preparing this salt, if sufficient nitroprussic acid has not been added in the first instance to convert the whole of the nicotine into the acid salt, some of the neutral one will remain after the separation of the crystals of the former salt, and on the further addition of the acid a fresh crop of crystals of the acid nitroprusside will be obtained. But a much better way of forming this and other acid nitroprussides of the alkaloids would be to take two equal portions of nitroprussic acid, and, having neutralized one completely with the alkaloid, to add to it the other, when at once the desired end would be obtained.

Nicotine forms a neutral salt also with nitroprussic acid; for when that acid is carefully added to an aqueous solution of that base, a neutral mixture may be obtained, which, on evaporation under a bell-glass *in vacuo* with sulphuric acid, yields a dark reddish-brown syrupy residue, exhibiting no disposition to crystallize, and evolving a strong odour of nicotine, and on further drying forms an almost black resinous-looking mass.

This dissolves readily in water, forming a dark-brown neutral solution, which on heating gives off a strong odour of nicotine, and

gradually becomes more and more acid in its reaction from the formation of a small quantity of the acid salt. And this neutral compound will, on the addition of more nitroprussic acid, furnish crystals of the acid salt. Though I have not yet determined the proportions of base and acid in this nitroprusside, there can be no doubt that there are two molecules of the base combined with one of the acid, as in the case of the neutral salts of the other alkaloids. And I may further add, that the same neutral salt was likewise obtained by the action of silver nitroprusside on a neutral solution of nicotine chloride.

Though the foregoing observations, as I am fully aware, leave much yet to be done in the direction I have been pursuing, still I thought it better, before the close of the session, to make this preliminary report, embodying the results I have already obtained in investigating some of the organic salts of nitroprussic acid. But I trust that before long I may be able to extend my observations, not only as regards the alkaloids, but to other organic bases, when I hope to lay my results before this Academy in a more complete and perfect form.

versely into mountain chains, with intervening desert platforms. Its southern extremity is formed by the Himalayan and other ridges; their general level, from 20,000 to 24,000 feet in altitude, culminating in still loftier peaks, some not far short of 30,000 feet. All the transverse ridges, in a great portion of their length, have an east and west course; while their terminations generally curve northwards.

The development of High Asia is a vastly complex phenomenon, presumably resulting from disturbances which have been directed along different zones of weakness. The zone in correlation with equatorial jointing seems to have been the medium through which the transverse ridges and their individual igneous axis were upheaved; while those referrible to the two principal sections of meridional jointing may have similarly influenced their terminations on both sides of this huge plateau, especially in the region east of it; where mountain ranges, coast-lines, and off-lying islands all coincide in their strike with the east-of-north meridional jointing. The lofty parallel ridges east of Burmah, in being medio-meridional, are so far in conformity with the last-mentioned features. This abstract will scarcely permit of any reference being made to the equatorial extensions from the Pamir through Western Asia, &c.

Respecting another prominent feature of our continents, it is assumed that the east-of-north and the west-of-north sections of meridional jointing have primarily marked out the sides of the triangle, under which form these great land masses are for the most part presented; while the base of the triangle is ascribed to equatorial jointing. But it is not yet clear why the base of the triangle faces the north, and its apex points to the south. The writer thinks the solution lies in the fact that the greatest elevated land masses characterise the Northern Hemisphere and equatorial regions; a disposition which would cause a greater width of elevated land to lie within the basal area of the triangle than at the apex.

The question next suggests itself, arising from a consideration of all the phenomena noticed in the memoir,—if the original elevated plateaus have always existed as masses, having an elevation far above the bottom of the great intervening depressions (oceans)—how have they become covered up with oceanic sediments thousands of feet in thickness, and representing successive geological periods? In this connexion it is argued that elevations of rock-masses are of two kinds:—one due to stratial disturbances, which for the most part have been exerted horizontally, or approximately so; and the other to vertical movements, extending over wide geographical areas. The author's early attention was called to the latter class of movements by the beautifully developed series of terraces in the Burren of Clare, reaching to the height of nearly 1200 feet. He ascribes this particular instance to a slow upheaval of the district above the sea, the surface of each terrace representing the bottom of a shore-line—a plane of marine denudation, and an apparent stoppage in the upheaval. The terraces of

Lochaber have been examined by him, with the result of his having become convinced that they are ancient sea-margins: 1495 feet is the height usually stated of these terraces; but he detected on the flanks of Ben Nevis and the opposite mountains the like features, which must reach to an altitude of between 2000 and 3000 feet. Besides the raised shell-beaches standing at a comparatively low level on the coasts of Norway, terraces have been lately observed and described by Dawkins, which occur on the Dovrefelds, at the heights of from 2000 to 3100 feet. Darwin's account of the remarkable examples that occur in Patagonia, up to the height of 1300 feet, leaves no doubt on the present writer's mind that they have been formed by the action of the sea. Hector has described vast terraces on both the Atlantic and Pacific slopes of the Rocky Mountains, stretching from Athabasca River to Mexico, and rising one above another to heights ranging from 3500 to 4500 feet above the level of the sea. The late Daniel Sharpe made known the occurrence of lines of erosion on the inner and outer flanks of the Swiss Alps, at about 4800, 7500, and 9000 feet above the sea. And, to finish what could be made a much longer list, Rudolph Griesbach has described terraces in Natal lying at heights of about 1000, 2300, and 5000 feet: it would also appear that these correspond with certain of the plateaus common in the Cape Colony. In short, it may be safely stated that marine terraces are to be seen in every region of the globe.

In the deep valleys of the lofty southern buttress—Great range of Thibet—terraces ascend to the height of 16,000 feet; but as these may have been formed along the shores of elevated lakes, such as are now in Ladak and adjacent countries, it would be unsafe to classify them with the marine representatives that have been noticed.

The writer, nevertheless, maintains that a number of geological evidences afforded by the vast area last noticed, combined with the proofs already brought forward, establish the conclusion that vertical movements, equal to hemispheres in extent, have affected not only High Asia, but the entirety of the earth's surface; elevating continents, including their mountains and plateaus, at the same time uplifting the bed of the intervening oceans, thousands of feet above their present level; or plunging them as deeply in the opposite direction.

Without denying that the level of the sea may have undergone great fluctuations at intervals during past geological time, and that such changes may have participated, to an extent far beyond what physicists and hydrographers are at present disposed to admit, in effecting phenomena which, for convenience sake, he collectively ascribes to vertical movements in the earth's crust,—or, without offering any opinion respecting the hypotheses suggested by Babbage, Herschel, and others, as to the cause of phenomena of elevation,—it does not appear improbable to the author that vertical movements have by slow degrees, and during a series of vast chronological terms, alternately elevated and depressed opposite areas corresponding in extent with a hemispherical division of the globe.

To illustrate this view, let it be assumed that one of our hemispheres, having attained its maximum elevation, is next to undergo subsidence. During this elevated period the *land surfaces* of moderate height would be in what may be termed the *first* stage of depositional action, viz., the formation of subærial, fresh-water, and estuarine deposits: in the *second* stage they would be under marine conditions, producing littoral and deepish-water conglomeratic, arenaceous, argillaceous, and calcareous beds: in the *third* stage they would be under pelasgic conditions, developing limestones, argillites, and siliceous rocks. Next, elevation having supervened, the *fourth* stage would be a repetition of the second, yielding comparatively shallow-water marine deposits, and terminating by passing into the first stage. Thus would our continents, notwithstanding their being at present at an average height of a few thousand feet above the sea-level, become over-laid by vast deposits of all kinds—those of any given stage being the equivalent of one of the formations, usually four, which constitute a geological system of rocks (take, for example, the Carboniferous System); and, moreover, the whole agreeing with the formations of a system in their usual order of superposition.

A few points must be briefly added. It is not assumed that all great vertical movements have proceeded in the invariable course, and to the extent, vertical, or areal, as above illustrated; nor that they were unaccompanied by minor ups and downs. The hemisphere opposite to the one given as an illustration would be undergoing counter vertical movements. As to the deposits which were thrown down over the abysses of the oceans (Atlantic and Pacific) when the continents were under pelasgic conditions, it is admitted they involve some questions difficult to answer, whether considered in connexion with Dana's hypothesis, or the author's.

Obviously great recurrent climatal changes would result from these elevations and depressions; severe glacial conditions accompanying the one, and the replacement of the latter by genial ameliorations consequent on the other.

The consideration of these points gives rise to the question, often debated ;—how has it happened that after the Pliocene period climatal conditions prevailed which converted a great portion of Europe and North America (there are grounds for excepting Northern Asia) into ice-covered regions; and that during the Miocene, or probably some portion of the Pliocene period, areas lying frem 10° to 20° of the North Pole, as it appears to some geologists, have enjoyed a climate approaching in genialness that of the south of Europe at the present day. The writer, rejecting all the hypotheses that have been offered in explanation of these climatal interchanges, maintains that they are mainly due to the afore-mentioned vertical movements.

Confining himself to the climatal conditions which characterised Grinnell Land, Spitzbergen, and other Arctic areas during the Miocene period, as indicated by their plant-remains, he suggests that these and adjacent areas stood at a somewhat lower level relatively to the sea than at present; and formed an archipelago, freely permitting

currents, with a temperature slightly more elevated than that of the gulf-stream where it now strikes the west coast of Ireland, to bathe the coasts of its islands. Climatal amenities now prevail in Northern Scandinavia, the Kara Sea, and the Taimyr peninsula of Asiatic Russia: the last place, the most northern continental land of the globe, now supports an exuberant forest vegetation in a much higher parallel than anywhere else within the Arctic circle, and only about 16° short of the North Pole: while the fact is evidently due to the presence of warm water carried by ocean currents, and by rivers (as the Yeneissi) from the south. Northern Siberia, in direct communication with southern lakes and ocean streams, charged with warm water, and in the condition of an archipelago;—why may not its great forest belt be extended up to Spitzbergen and Franz Joseph Land—to parallels corresponding with those in Grinnell Land, which formerly supported the growth of a vegetation approximately similar in some respects to that now characteristic of Northern Italy and the Southern States of North America?

As to the long winter-night of darkness, and the long summer-day of sunlight, he is satisfied from adducible evidences, that, other things being favourable, such conditions would rather favour than impede vegetable growth.

The memoir concludes with remarks on igneous disturbances. Admitting the existence of a number which may be included in the equatorial system of jointing, it is stated that disturbances of the kind are for the most part limited to certain of the meridional zones of weakness. As is well known, a most important series of volcanoes characterises the west coasts of the two Americas, and a similar series lies off the east coast of Asia; belonging, in the author's opinion, one to the west-of-north, and the other to the east-of-north section: both series become united in Behring Sea. Other writers, by connecting the equatorial series of volcanoes north of Australia with the above two, have constructed a "circle of fire," but, according to the present writer, with far too limited a range. He contends that the two meridional series (by pursuing a direct course, so as to embrace the Cocos Island, St. Paul's, Kerguelan's Land, Enderby's Land, thence curving to Trinity Land, passing on to the South Shetlands, and through Fuejia into the Patagonian Andes), form but one—a great volcanic girdle; which may be said to stretch without interruption around the world, traversing the Arctic regions a few degrees east of the North Pole, and intersecting the Antarctic circle at a corresponding distance west of the South Pole; thus dividing the crust of the globe along its greatest zones of weakness into two nearly equal halves.

As to reflections which may naturally arise in connexion with the last subject, it may be remarked that the writer is, scientifically, too much of a teleoptomist, too extravagant a timist, and too little of a catastrophist, to entertain any involving serious or disquieting apprehensions.

LIII.—On some Anomalous Structures in Human Anatomy. By J. F. Knott, F.R.C.S.I., L.K.Q.C.P.I., Demonstrator of Anatomy, Royal College of Surgeons, Ireland.

[Read, December 8, 1879.]

The anomalous structure to which I have the honour of calling the attention of the Members of the Royal Irish Academy was discovered in the dissecting-room of the School of the Royal College of Surgeons.

I had been assisting in the dissection of the spinal cord and the ligaments of the vertebral column of the subject on which it was found. Those of the two upper vertebræ were left till the last, as I

Fig. 1 represents the parts, and gives a good idea of the connexion of the ligament in question with the upper margin of the transverse ligament—*a*, superior appendix of cruciform; *b*, upper part of transverse ligament; *c*, ligamentum transversale occipitale.

had already intended to examine them with special attention. The posterior part of the occipital bone had been removed in the course of the dissection, as well as the laminæ of all the vertebræ. The *posterior common ligament* of the spine had been examined, and its prolongation into the cranium through the foramen magnum traced along the upper surface of the *clivus* as far as the upper margin of the *dorsum sellæ* and the posterior clinoid processes. After the removal of this structure the *apparatus ligamentosus* was defined, but no peculiarity was observed to exist either in its structure or attachments. This having been in its turn taken away, and the subjacent bursa examined, I proceeded to define the outlines of the cruciform

ligament. I now observed what I at first took for a disproportionate increase in the depth of the transverse ligament. On examining more carefully, however, I soon found that the upper bundle of transverse fibres, which caused the apparent increase in depth of that ligament, was attached—not to the lateral masses of the atlas, but—to either margin of the *foramen magnum*, and formed a strong, rounded, and perfectly separate ligamentous cord, stretching across the *foramen magnum* from the posterior part of the tubercle for the check ligament on one side to the corresponding point on the other. Its lower margin, which had at first sight appeared to be fused with the transverse ligament, was found to be easily separated from the latter, as the adjacent margins of the two structures were merely connected by a little loose areolar tissue. The *appendix superior* ascended from the upper margin of the transverse ligament, behind the other band, to its usual point of attachment.

Fig. 2 gives a good idea of its relation to the check ligaments: the latter were exposed by division of the other ligaments connecting the atlas with the occipital bone, and then separating the two bones by traction—*a*, superior appendix of cruciform; *b*, upper part of transverse ligament; *c*, ligamentum transversale occipitale.

When the latter structure was forcibly drawn upwards from the upper margin of the transverse ligament, the apex of the odontoid process was brought into view, and the check ligaments were seen proceeding therefrom, one on either side, obliquely outwards and upwards, with a slight inclination forwards to their usual points of attachment, which in this case was immediately in front of, and indeed partially blended with, those of the ligament which forms the subject of the present communication.

Having never before met with anything similar to this ligamentous band, my curiosity was considerably excited by its appearance, and this feeling was not diminished when I found, on showing

the specimen to Professor Macalister, that no corresponding structure had been observed by him before. He informed me afterwards, however, that a ligamentous band, having the position and attachments of the one in question, was described by Lauth as a normal structure in human anatomy. Lauth has given it the name of *ligamentum transversale occipitis*, and describes it in the following words:—"Unmittelbar über diesen Bändern[1] findet man das Queerband des Hinterhauptbeins (L. transversale occipitis), welches von einer seite des Hinterhauptloches an die andere geht, ohne sich an den Zahnfortsatzes zu heften."—(*Anatomie*, Bd. i. s. 101).

I have since found that it is noticed in the French work of Beaunis and Bouchard under the name of "*ligament transverse occipital de Lauth*" (8^{me} ed. p. 133). These anatomists look upon it as being formed by the superior fibres of the check ligaments, passing, as they describe it, without interruption from one occipital condyle to the other, over the summit of the odontoid process. Luschka, in his very perfect description of the anatomy of this part, also observes that it is not unusual for the uppermost bundles of fibres of the check (superior lateral) ligaments to interlace with one another so as to form an *upper ligamentum transversale*. From his description, however, I am not disposed to think that he ever saw it largely developed as an independent structure. Henle (Bänderlehre) also describes an inconstant *membranous* band formed by a few of the fibres of the check ligaments interlacing with one another in the middle line behind the upper part of the odontoid process, and so stretching across from one occipital condyle to the other; but even he does not mention any case in which it had been seen to attain anything like a considerable size, although he quotes all the known deviations from normal structure in this as well as in other regions of the human body. A slight allusion is also made to the interlacement of some of the upper fibres of these ligaments in *Quain's Anatomy* (8th ed.), but not in such a manner as to lead the reader to expect that a strong separate band might be found in this situation.

From the evidence brought forward, I think myself justified in describing the specimen before the Academy to-night as an anomalous structure, and one of some interest, as must all the structures be, normal and abnormal, which enter into the formation of the very important articulations which connect the vertebral column with the brain-case, and which, accordingly, are concerned in the preservation of the vital structures which lie in their immediate neighbourhood. I should, however, have hesitated to bring it under the notice of anatomists if I had not been encouraged by Professor Macalister; to whose kindness and courtesy I am indebted for the chief part of the information which I have been able to collect on the subject.

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[1] *i.e.*, Ligamenta alaria.

LIV.—NOTE ON THE OCCURRENCE OF A PREMAXILLO-FRONTAL SUTURE IN THE SKULL OF THE KOALA (PHASCOLARCTOS CINEREUS). By H. W. MACKINTOSH, Professor of Zoology, Trinity College, Dublin. (With Plates X. to XIII.)

[Read, November 29, 1879.]

IN the collection of the Museum of Anatomy and Zoology of the University there is a skeleton of the marsupial Koala (*Phascolarctos cinereus*, Fischer), the skull of which, while normal in other respects, exhibits a distinct contact between premaxillæ and frontals, an arrangement which, so far as I can ascertain, has not yet been described. The animal to which the skeleton belonged had been obtained some years ago by Professor Macalister (to whose courtesy I owe the present opportunity of describing the skull), who published an account of its anatomy in the *Annals and Magazine of Natural History for* 1872, Vol. x. p. 127.

In the Museum of the Royal Dublin Society there is another skeleton of Koala, the skull of which Dr. Carte, the Director of the Museum, has kindly allowed me to examine; and in it I find also a premaxillo-frontal suture, but it is apparent only on the right side, where it is very small, being less extensive than that on the left side in the specimen here figured. In their general features they both agree with the descriptions given in manuals and memoirs, and on comparing them with the drawing published by Owen,[1] I find that the resemblance is sufficiently close in other respects.

In its cranial osteology the genus Phascolarctos departs, as is well known, from many of the characters of the Didelphs, and suggests sundry resemblances to Monodelphian skulls. Thus, for instance, the zygomatic arches are very long, and run parallel to the axis of the cranium, as in no other living marsupial, and only to a comparatively slight degree in the fossil Nototherium. Then we notice the large tympanic bullæ (which have been compared to those in the pig), the abruptly truncated nasal aperture, the rounded premaxillæ, the prominent paroccipital processes, and the vertical supra-occipital, all rodent characters, and each of which connects the Koala with some other marsupial genus, as I shall presently point out.

On examining the anterior part of the skull (Plate X., fig. 1), it will be seen that the ascending process of the maxilla (7), which, in all the other marsupials which I have examined, comes into contact with the nasal (8) of its own side, and interposes between the premaxilla (9) and frontal (4), is here shorter than usual, and thus these two bones come into contact slightly, but distinctly, on the right side, and to a much more marked degree on the left. In a skull of the same animal,

[1] "On the Fossil Mammals of Australia," *Phil. Trans.*, vol. clxii. part 1.

in the Museum of the Royal Dublin Society, the arrangement differs slightly from this, for there the suture on the right side is present, though much smaller than that figured above, whilst on the left side a very small bar of bone, not more than one-twentieth of an inch in width, runs across from the frontal to the maxilla, and prevents the contact of premaxilla and frontal.

As there are only the two skeletons of the Koala in Dublin, I cannot say whether this suture is characteristic of the genus; but in the drawing of the skull published by Owen[2] there is no appearance of it, nor in the various allusions to it which I have met with can I find any notice of it. On the contrary, it is generally laid down as a character of the marsupials, that the premaxilla never quite reaches the frontal, so that I am inclined to think that its presence in these two specimens is due rather to individual variation.

As regards the degree of extension of the premaxilla on the upper surface of the skull, there is a good deal of difference amongst Didelphs, as may be seen by the figures which I have drawn from specimens in the Museum of Anatomy and Zoology. Thus *Phascolomys fossor* (Plate XIII., fig. 8) has the largest premaxilla,[3] which exceeds that in *P. latifrons*, Owen (Plate XI., fig. 4). Next in order would seem to come *Phalangista vulpina*, Desm. (Plate XIII., fig. 9), where the premaxilla is of a massive character, like that of Phascolomys; then would come *Halmaturus ualabatus*, Less. (Plate XII., fig. 6), and its ally *Macropus gigantea*, Shaw (Plate XII., fig. 5), which scarcely, if at all, proportionally, exceeds *Sarcophilus ursinus*, Geoff. (Plate XIII., fig. 10); and finally, there is *Didelphys cancrivora*, Gomel (Plate XII., fig. 7), in which there is about the smallest extent of premaxilla, at least in the series which I have examined. There is, however, in the Museum a skeleton of *Petaurus ariel*, Gould, in which the premaxilla seems to reach very nearly, if not quite, up to the frontal; but the ossification of the skull has been so complete that the sutures are almost entirely obliterated, and I have not been able, in spite of careful examination, entirely to satisfy myself of their contact.

In comparing the skull of the Koala with those of other marsupial genera, we may notice that, while possessing strongly marked characters of its own, it presents many features which are repeated in the other forms. Thus we notice the parallel zygomata, as in Nototherium; the large tympanic bullæ, like those of Petaurus; the large par-occipital processes, which resemble those in the Kangaroo, to which there is a further likeness in the rounded premaxillæ; the vertically placed supra-occipital, as in Phascolomys, and the truncated nasals resembling those in Sarcophilus.

A premaxillo-frontal suture does not appear to be common amongst mammals, nor, indeed, amongst vertebrates. It is to be

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[2] "On the Fossil Mammals of Australia," *Phil. Trans.*, vol. clxii. part 1.

[3] Owen says that Phascolomys has the largest premaxilla, but he seems not to have met with a Koala with a premaxillo-frontal suture.

found, so far as I know, generally in Cetaceans, in the elephant, and, as a rule, in Rodents, the hares being a frequent exception. I have observed a very small, but distinct, suture on both sides of the skull in the hedgehog, but it does not exist in the specimens of Centetes and Myogale, which are the only other genera of Insectivora, the skulls of which are in the Museum. In all the other classes of mammalia the premaxillæ are either small, or even when of considerable extent are prevented from reaching the frontals by the greater development of either nasals or maxillæ.

DESCRIPTION OF THE PLATES.

The following references are adopted throughout:—

1. Supra-occipital.
2. Parietal.
3. Squamosal.
4. Frontal.
5. Jugal.
6. Lachrymal.
7. Maxilla.
8. Nasal.
9. Premaxilla.
10. Tooth.

PLATE X.

Fig. 1.—Skull of Koala seen from above, showing the premaxillo-frontal suture well marked on the left side, and its extension on the right.

PLATE XI.

Fig. 2.—Anterior part of same skull, right side.
Fig. 3.—Anterior part, left side.
These figures are slightly enlarged, and are introduced to show the relations of the premaxillæ and frontals, without the fore-shortening, incident to a top view.
Fig. 4.—Anterior part of skull of *Phascolomys latifrons* seen from above.

PLATE XII.

Fig. 5.—Anterior part of skull of *Macropus gigantea* seen from above.
Fig. 6.—Anterior part of skull of *Halmaturus ualabatus* seen from above.
Fig. 7.—Anterior part of skull of *Didelphys cancrivora* seen from above.

PLATE XIII.

Fig. 8.—Anterior part of skull of *Phascolomys fossor* seen from above.
Fig. 9.—Anterior part of skull of *Phalangista vulpina* seen from above.
Fig. 10.—Anterior part of skull of *Sarcophilus ursinus* seen from above.

The figures from Plate XI., fig. 4, to Plate XIII., fig. 10, are intended to show the extension upwards of the premaxilla towards the frontal in the different genera and species which I have been able to examine. All the figures are natural size, except figs. 2 and 3, which are slightly enlarged.

LV.—Eurites, or Basic Felstones of Silurian Age. By G. H. Kinahan and Gerrard A. Kinahan.

[Read, April 26, 1880.]

In the Irish Silurians, that is, including under this name both the rocks containing the typical Silurian fossils, and also those commonly called Lower Old Red Sandstone (the "Glengariff grits," and "Dingle beds" of Jukes), there are felstones which seem to be typical of the formation. They are basic, the "Eurites" of Daubuisson (from *eureo*, to flow easily, on account of the facility with which they melt before the blow-pipe), and belong to the "Hybrid rocks" of Durocher. The geological position of the Silurian eurites is fully given in the Report on the Rocks of the Ballaghaderreen and Fintona districts.

In Munster, the granitic roots of these rocks have not been observed, although in places in the intrusive portions they partake more or less of elvan characters, as they contain free quartz; in Galway, however, they can be traced down into a true granite, and in N. E. Mayo into elvan; while in Tyrone there are granites and elvans which are evidently the granitic roots of the interbedded eurites. What may be an important character in these rocks is the presence of carbonates of iron and lime; sometimes abundantly. In this Report, it is proposed to describe some of the euritic rocks of Kerry, N. W. Galway, and S. W. Mayo.

We are indebted for valuable aid to Professor O'Reilly, M.R.I.A., of the Royal College of Science, who allowed us the use of his well-arranged mineralogical laboratory and his microscopes, besides free access to his excellent type collections of rocks, minerals, and microscopic slides.

During our examination we have consulted several works on the microscopical study of rocks, especially those of F. Rutley, on *The Study of Rocks*; F. Zirkel, *Microscopic Petrography*; and F. Fouqué, *Santorin et ses eruptions.*

Part I.—*Rocks of Kerry, N.W. Galway, and S.W. Mayo.*

In the counties Kerry and Cork, south of a line drawn east and west along Dingle Bay, the Silurian rocks are of the type called by Jukes "Glengariff grits." In these rocks there are masses of eruptive rocks appearing in the vicinity of Valentia harbour, and southward of Killarney, in the neighbourhood of Lough Guitane, between Mangerton and Glenflesk.

In the vicinity of Valentia harbour the majority of the eruptive rocks are so basic that they must be classed as either gabbros or dolerites; but those near Lough Guitane are eurites of Daubuisson, and belong to the typical basic felstones of the Irish Silurians.

From the latter area two specimens are exhibited; both show the gradual merging of the rock into elvan, as they contain free quartz. This, however, might be expected, as one of the specimens is from the intrusive mass, while the other is from the vicinity of it.

That from Lough Guitane, near Killarney, is a specimen of a dark-green feldspathic rock; it has a specific gravity of 2·63. The macroscopic examination of it shows it to consist of a finely granular ground-mass or matrix, scattered through which are small crystals of feldspar, some of which appear to be orthoclase, while others are triclinic; some have striæ on the basal section, some are of an opaque white, with bluish tinge; there are also crystals and blebs of quartz. On looking through a thin section of this rock, a structure appears in the ground-mass which might be described as a banding, being a series of alternate semi-opaque and more pellucid parallel bands. The feldspar is cloudy, the quartz clear.

Microscopically, the ground-mass of this rock consists of a crypto-crystalline base, with numerous crystallites of feldspar (both orthoclase and triclinic) quartz, small fragments apparently of hornblende; in some places long acicular crystallites or crystalloids, sometimes grouped radially, which are clear and pellucid. A chloritic mineral (viridite), and a dusty-looking opaque granular mineral (opacite) occur plentifully, ferrite sparingly. In a few places aggregate polarization occurs, consisting of a clear, circular portion with a dark cross, which rotates on rotating the polarizer, but remains stationary on rotating the slide. The banding noticed in the macroscopical examination seems, with polarized light and under a power of one hundred diameters, to be due to a difference in the degree of crystallization, the more largely crystalline bands being the more pellucid. In this ground-mass are developed the macroscopical crystals of feldspar and quartz. The feldspars, as already mentioned, are both orthoclase and triclinic; some of them being very peculiar, showing a remarkable banding or interlamination under polarized light. Under ordinary light they appear rather clouded, from containing opacite; some of them are imperfect, and seem to have been broken subsequently to their formation, some of the ground-mass having evidently intruded between the fractured portions. The bright little specks occurring in these feldspars under polarized light are found, when examined under a higher power (300 diameters), to be little iridescent patches, and are probably thin films of calcite. On applying hydrochloric acid to the specimen, a slight effervescence takes place, about and along certain lines in the feldspars, and at little specks through the ground-mass, indicating, probably, films and specks of calcite. Large quartz crystals are not well represented in the slide; generally the quartz is in small, rounded patches, though in some cases in well-crystallized forms; all are clear. Some of the larger pieces contain stone enclosures.

The specimen from Binaunmore, Co. Kerry, is that of a compact, olive-green rock, having a specific gravity of 2·63. The ground-

mass or matrix shows a minutely granular texture; in it are enclosed small rounded blebs of quartz, with crystals (some twins of the Carlsbad type) of orthoclase and of triclinic feldspars; some of the latter are like labradorite. In thin sections the feldspars are generally of an opaque white, and are apparently much altered. There are also small fragments of a greenish mineral, having their longer axes lying in one general direction, giving the slide a foliated appearance. In the specimen a few crystals of a green earthy mineral are visible, probably an altered hornblende.

Microscopically, the ground-mass of this rock is cryptocrystalline; that is, though evidently crystalline, the component minerals are not recognisable. Scattered plentifully through it is a fine opaque dusty-looking mineral (opacite), and a green chloritic mineral (viridite), which, together, give the slice a banded or fluidal structure, circling round and tailing out behind the larger crystals. Scattered through the ground-mass are the macroscopic crystals of feldspar, which, in general, have not sharply-defined angles. In many cases, under ordinary light, they have very much the same structure as the surrounding matrix, being scarcely distinguishable from it, except on account of a clearer margin along the boundary, while in other cases they are more impellucid than the matrix; but under polarized light they are plainly discernible; as under crossed Nicols the matrix presents a speckled grey appearance, while the feldspars are either of a uniform light tint, or else exhibit the banded structure, with iridescent specks, as detailed in the description of the Lough Guitane rock. The quartz is clear, but contains bays and enclosures of the matrix (stone enclosures).

At Clogher Head, Dingle Promontory, the eurites appear to be interstratified with rocks containing typical Silurian fossils. The specimen taken thence is a pink-brown-coloured eurite, having a specific gravity of 2·71. The ground-mass is a pink-brown feldspartic matrix, through which are scattered small crystals of orthoclase (some Carlsbad twins), and triclinic feldspar (probably both labradorite and oligoclase). These crystals are mostly long and slender; but some are broken, apparently along a twin plane, and the ground-mass is forced in between the fractured portions. In thin sections there is a banded appearance in the slice, some of these bands being more impellucid than the rest; they lie in one general direction. On treating the specimen with hydrochloric acid, effervescence takes place around some of the triclinic feldspars, also along lines or cracks, and at little specks through the ground-mass.

Microscopically, the ground-mass is composed of a microfelsitic base, containing small crystalline particles of quartz, feldspar, viridite, and opacite, exhibiting a slight fluidal structure. Through this microfelsitic base are bands having a microcrystalline structure, composed of quartz and feldspar; and through this ground-mass are developed porphyritically crystals of orthoclase feldspars, more or less clouded, with twinning, some being broken. There are also feldspars

exhibiting the interlamellar structure described in the previous rocks. Most of the crystals contain numerous enclosures, some of which are recognizable as chlorite and opacite. Alteration appears to have taken place extensively through the mass; secondary products, some of which appear to be calcite, occur, filling up the interstices.

At Loughnafooey and the adjoining country, both in Galway and in Mayo, are large tracts of eurites and their associated tuffs, partly intrusive, but generally interbedded. The specimen examined is from one of the intrusive portions, and has a specific gravity of 2·62. The ground-mass or matrix of this rock is very slightly granular, and through it are scattered fragments of quartz, as also rounded portions of a waxy-looking feldspar, probably triclinic; in some of these an effervescence takes place, when the specimen is treated with hydrochloric acid, probably due to films of calcite in cracks through the minerals. Small earthy portions, having the form of orthoclase, occur through the mass, as also fragments of a dark-green mineral.

Microscopically, the ground-mass is cryptocrystalline, and through it occur fragments and crystals of quartz, feldspar, and microlithic portions of hornblende. Ferrite is sparingly represented; opacite occurs plentifully, particularly round the edges of the quartz. The feldspars are, for the most part, more or less decomposed, but triclinic twin structure is still apparent in many; in others there is left but an outer shell, the whole interior being replaced by an earthy, almost impellucid, substance. In places there are fragments of calcite; in one case, a fragment of what was apparently once feldspar is now represented by calcite. Apatite is recognizable in long acicular crystals in some of the more pellucid feldspars. Some of the feldspars show the interlamellar structure before described. The fragments of quartz are clear, and contain some large stone enclosures and glass cavities.

In the Silurians north of Killary Harbour, at Bundorragha, and to the west and east thereof, there are thick interbedded masses of eurites, from one of which the specimen now to be described was taken, the rock having a specific gravity of 2·66. There are some remarkable differences between this rock and that next to be mentioned; as, although both are from the same neighbourhood, there is in the latter a considerable quantity of carbonate of iron, although at the same time its specific gravity (2·60) seems to be lower. The ground-mass is a dense purple-brown matrix, having a slightly resinous lustre, through which are scattered crystalline particles, which, though tolerably abundant, are relatively small, and consist of quartz and feldspar, the latter mostly having a pearly lustre; some present a structure that is very like that of labradorite. In thin sections the ground-mass appears brown and fine-grained; and scattered through it are some comparatively large crystals and patches of quartz, containing stone enclosures, as also numerous small patches of clouded feldspar.

Microscopically, the ground-mass might be described as a micro-

Cambro-Silurian age of the Pomeroy fossiliferous rocks is conceded, it simplifies the matter; as the rocks in the hills to the north and north-west are much older, and must, therefore, belong either to the Cambrian or an older formation. To the northward and north-westward sides of the altered eruptive rocks of the hills there is a considerable thickness of apparently overlying schists, generally supposed to be metamorphosed Cambro-Silurian.

The conclusions I have drawn from the apparent stratigraphical position of the rocks now under consideration seem to be strongly confirmed by the petrological characters of the eruptive rocks associated with them.

In Craigballyharky and its neighbourhood the rocks are principally varieties of hornblende rock, that is, basic eruptive rocks and tuffs, which have been changed by metamorphic action. These, as is usually the case, are very variable in composition; as, however, they are more or less similar to the different varieties of hornblende rock in West Galway, elsewhere described,[1] it is unnecessary to re-describe them here. Traversing and breaking up through these rocks, especially in Craigballyharky, are veins of Galway granite of the "Omey type," and a black granite, very like one found near Furbogh and in other places in West Galway, except that in the Co. Galway amphibole and titanite are not uncommon in it, while in the Co. Tyrone they seem to be rare.

In the neighbouring hills (Craigardhessiagh and Garragrim) the rocks, for the most part, belong to an intrusion of the "Omey type" granite. They are, however, more or less cut up and traversed by dykes and courses of a very siliceous compact granite, common as a vein rock in Galway, and similar to the rock called granitite by Rose. The mass of the granite in this hill has been called "Syenitic granite," by which, I suppose, hornblendic granite is intended. The rock, however, seems scarcely to come under this classification, as its essential constituents are quartz, two, and in places three, feldspars, black and white micas, the first predominating; pyrite, and in places amphibole: the last, however, seems to be more an accessory mineral than an essential. In every respect this rock agrees with that described in the *Memoirs of the Geological Survey* as the "Omey type" of the Galway granite.

In the western part of the district now described, the rocks are principally varieties of hornblende rock very similar to those found in Errisbeg, Errismore, and other places in West Galway; while here, as there, some of the rocks are changed by methylotic action into ophite, steatite, and allied rocks. These rocks in West Galway are found in the uppermost portion of the "Great Micalite series," which,

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[1] "Granitic and other Ingenite Rocks of Yar Connaught and the Lower Owle," *Proceedings R. I. A.*, 2nd ser., vol. ii., p. 102, *et seq.*

I think, are probably equivalents of part of the "Arenig group" of Wales, put by some geologists among the Cambrians.

These two lines of evidence, stratigraphical and petrological, point to the same conclusion, that these Tyrone rocks now in question are of Cambrian age.

It may here be mentioned incidentally, that breaking up through these metamorphic eruptive and sedimentary rocks are masses of a much more recent granite, or elvan, similar to the pre-Carboniferous granite rocks at Carndaisy, Co. Derry, and more or less like the granite and elvan of Lugnanoon, Co. Galway. As this granite, in the intrusion near Mullanmore Bridge (north of Carrickmore, or Termon Rock), graduates into elvan, and the latter into a quartzitic eurite, closely allied in composition to the eurites which, south of Pomeroy and elsewhere, are interstratified with the arenaceous red Silurian rocks, we have a right to suppose that here, as in West Galway, and South-west Mayo, these granites and elvans are the granitic roots of the Silurian bedded eruptive rocks.

The second tract to which I would direct attention is in North-east Mayo, southward of Charlestown, and westward of Ballaghaderreen. The rocks of that area were classed by Griffith, and subsequently by Jukes, as ancient metamorphic rocks; but more recently they have been called "Felstones" and "Upper Silurian."

Mapping some of these rocks as felstones is so far correct, that the rocks so called are granulites, or leptynites (metamorphic felstone), rocks which many petrologists include among the felstones;[2] but mapping any of them as "Upper Silurian" must be incorrect, as it is evident that these metamorphic rocks were ruptured, upturned, metamorphosed, and denuded prior to the still unaltered Silurian rocks being deposited on them. In the conglomeritic Silurian rocks of Cranmore and elsewhere fragments of these metamorphic rocks are conspicuous.

These metamorphic rocks in the country southward of Charlestown are in many respects very like those in the Tyrone hills to the north of Pomeroy; but we cannot speak of them so confidently, because—

First, only a small tract is exposed, which at one side is overlaid unconformably by Silurian rocks, and on the other by Carboniferous; therefore, although we are aware that they must be older than the Silurian, yet we cannot positively prove that they do not belong to the Cambro-Silurian.

Secondly, in many respects they are more or less similar to some of the rocks of the *Doolough and Lettermullen series* (S. W. Mayo and West Galway), in which are fossils pronounced to be Cambro-Silurian.

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[2] Rutley says that granulite, or leptynite, has the same relation to felstone as gneiss has to granite.

What I, therefore, now put forward in respect to the Ca[m]
age of the rocks now in question is only conjectural. It
appear to me that they are a portion of the rocks which occur i[n the]
hills called Benbo and Slieveslish, south and eastward of Lough
Co. Sligo. These latter rocks are very similar to some of the
rocks in the West Galway section; rocks which, as shown in
Papers read before the Academy and elsewhere, are probably
Cambrians below the passage beds between the Cambrian and Ca
Silurian formations.

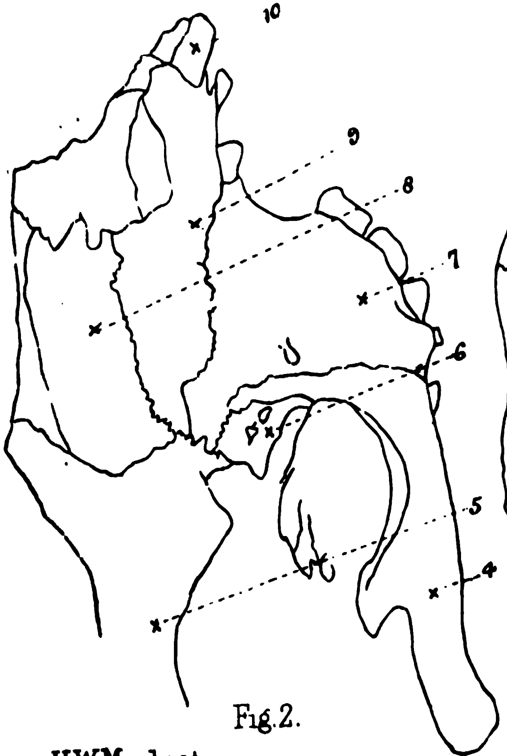
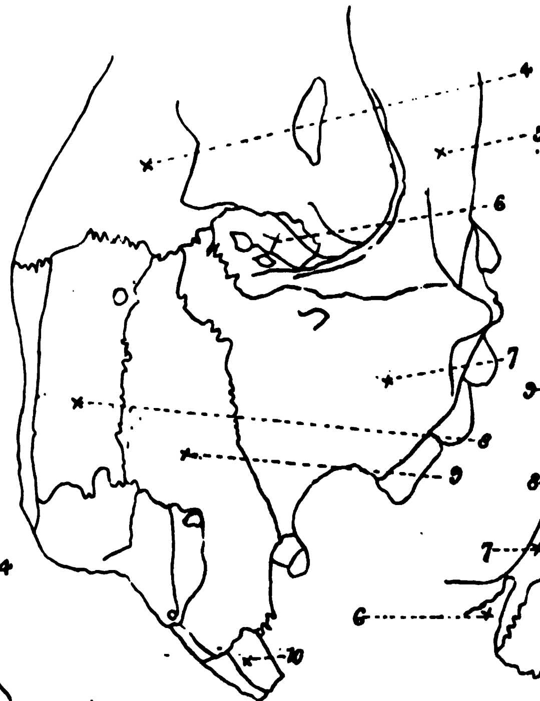


Fig. 2.



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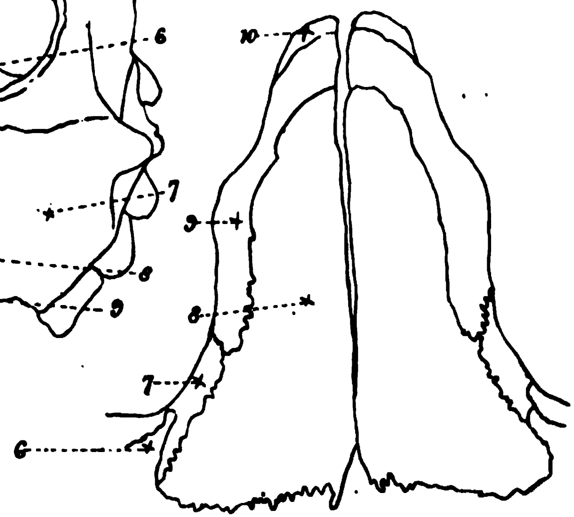

Fig. 4.

H.W.M. ad nat.

H.W.M. ad nat.

Forster & Co., Lith. Dublin.

therefore, now put forward in respect to the Cambrian rocks now in question is only conjectural. It would e that they are a portion of the rocks which occur in the Benbo and Slieveslish, south and eastward of Lough Gill, These latter rocks are very similar to some of the lower West Galway section; rocks which, as shown in former before the Academy and elsewhere, are probably Upper below the passage beds between the Cambrian and Cambro-rmations.

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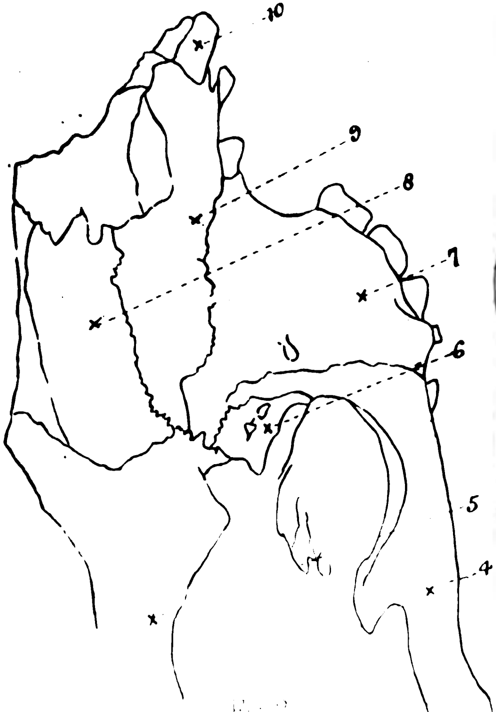

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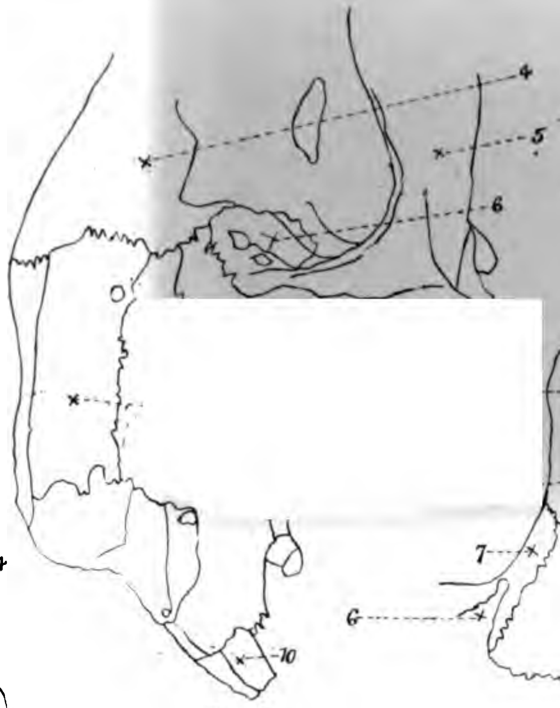

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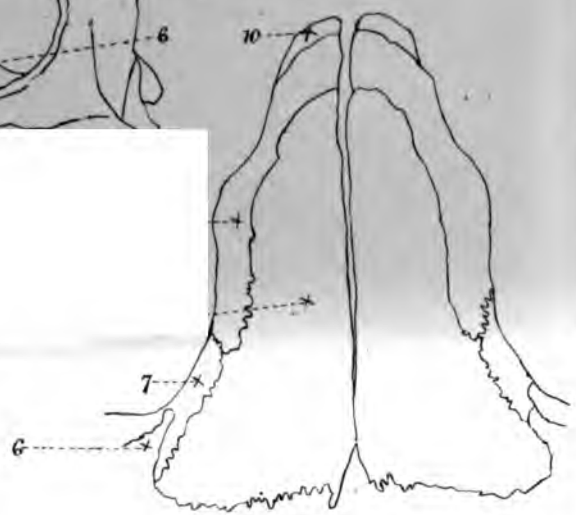

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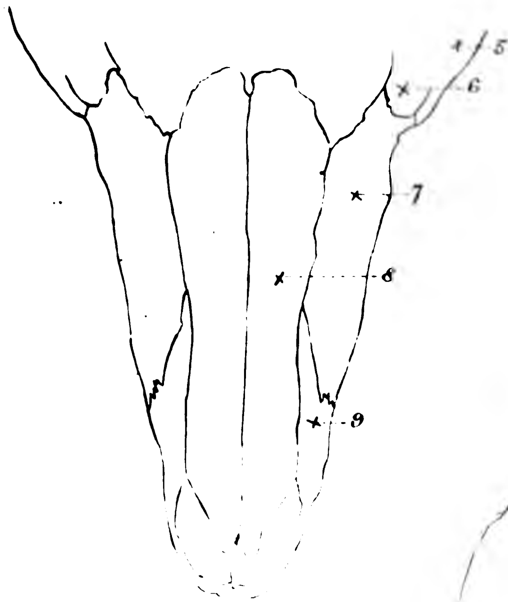

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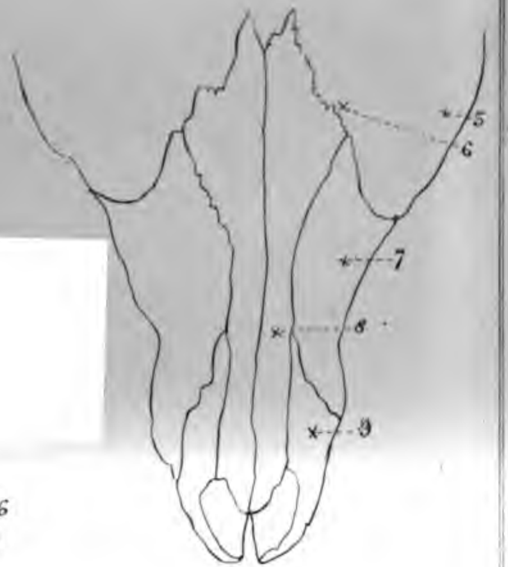

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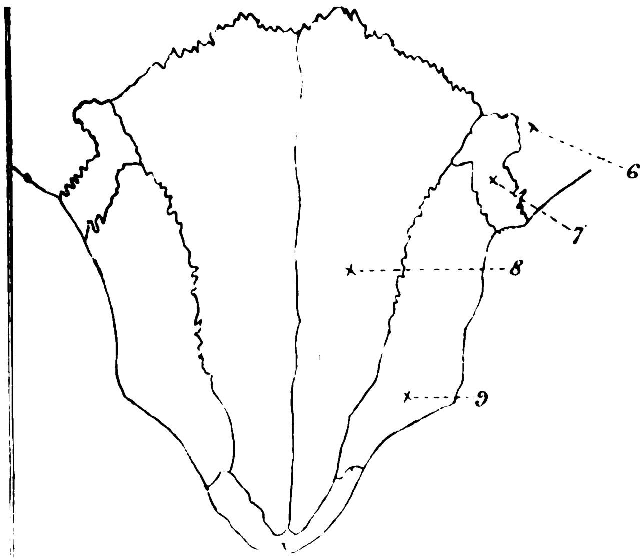

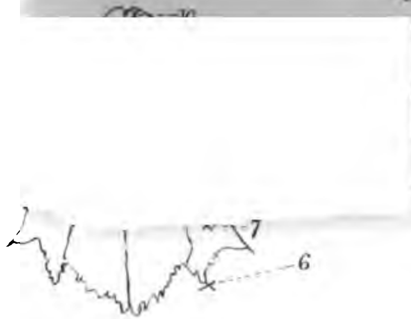

Fig.9.

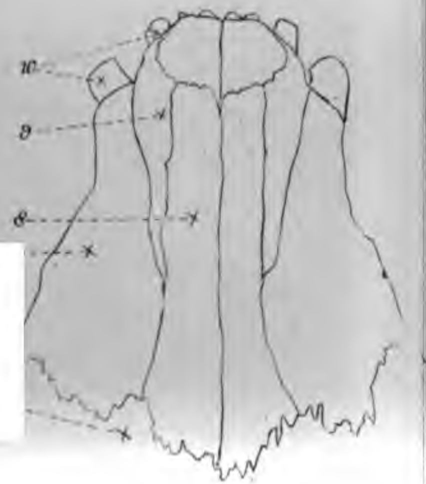

Fig.10.

LVII.—ON THE OSTEOLOGY OF TWO NEGROES. By ALEXANDER MACALISTER, M. D., Professor of Anatomy and Chirurgery, University of Dublin.

[Read, November 30, 1880.]

Two well-grown male adult Negroes were received, in the ordinary course of subject-supply, in the Dissecting Rooms of the University, and, as in this country the opportunities of such dissections are rare, I put their bodies into the hands of the most careful and senior of our students, who, under my constant personal superintendence, made very thorough examinations of all the systems of their bodies.

In this and the following short records I have summarized the results of the notes made by these gentlemen.

It is rather remarkable that while in the ordinary course of things it might be expected that Negroes would form a large proportion of the subjects dissected in America, yet the anatomists of that country have not given to us, in anything like an exhaustive manner, a record of the presence or absence of peculiarities. The few meagre anatomical notes hitherto published in that country are only sufficient to stimulate the curiosity of anatomists, not to satisfy it.

The Negroes were both of pure African descent, well developed, full-grown, born in the West Indies, sailors. No. 1 was smaller, older, about 44; No. 2 was 5 feet 11 inches in height, largely developed, younger, about 35. The skeletons of both have been carefully prepared, and are now placed in the Ethnological Collection in the College Museum. From these I have made the following notes:—

The skull of No. 1 is prognathous, dolichocephalic, mesoseme, platyrhine, hypselocephalic, mesorhine. Its facial angle, as measured by the alveolar index, is 1066, and its measurements are as follows:—

Fronto-iniac arch 310 mm., long diameter 178 mm.; intermastoid arch 370 mm., intermastoid diameter 128 mm., greatest width 131 mm.; height 139 mm.

The sagittal suture is partly ankylosed, simply toothed. There is a large left and small right parietal foramen; a small wormian bone in the parieto-mastoid suture on each side; a short sphenoparietal suture 13 mm. long on both sides. There is no posterior condyloid hole, and the condyles are unsymmetrical, the right being shorter and divided into two facets; the left longer and undivided. The right anterior condyloid hole is divided by a septum, and the jugular eminences are large, projecting on one side into a kind of paramastoid process, while there is a small spur in front of the left condyle like a trace of the third occipital condyle.

The temporals have large mastoid processes, a post-glenoid fissure, a bony bridge crossing the jugular foramen on each side internally,

and a smaller bony bridge passes from the carotico-jugular crest to the ex-occipital. The right foramen spinosum is in the line of the suture, and the scaphoid fossa is continuous down to the hamular process.

The nasal bones are prominent, ridged, narrow above and wide below; the lachrymal has a sharp crest, a middle and inferior process, a short lachrymo-ethmoidal suture 1 cm. long. The malar has a posterior temporal process, and the infra-orbital canal is very oblique, looking downwards and inwards, with a sharp crescentic outer edge. The anterior nasal spine is double and prominent.

The teeth are large, the lower molars with much-wrinkled crowns; the third lower has its fifth hindmost cusp large, and its other cusps divided by secondary furrows. The right third upper molar is nearly as large as the first, and a diastema, 6 mm. long, intervenes between the second premolar and the first molar on the right side above.

The lower incisors are strongly curved, concave backwards. The alveolar parabola of the lower jaw measures 57 mm. from before backwards, and 62 mm. transversely across the third molar. The semi-ellipse of the upper teeth is 50 mm. in its semiaxis major and 62 mm. in its axis minor.

The mandibles are large, strong, 87 mm. from angle to angle, 70 mm. in height at the condyle, which was 29 mm. in transverse breadth; the outer points of the two condyles were 125 mm. apart, while the inner were 77·5.

The skull of No. 2 was larger, finer, more massive, prognathous, dolichocephalic, cryptozygous, microseme, platyrhinal, and having the the following measurements:—Greatest length 188·5 mm.; greatest breadth, supramastoid 136 mm., interparietal 132 mm.; greatest height 140 mm.; fronto-iniac arch 350 mm.; intermastoid arch 380 mm.; orbital index 75·5; cephalic index 72·3.

In many respects it resembled that of No. 1, but showed the following differences:—

The coronal suture is uncommonly gyrated on each side, and the spheno-parietal suture is absent, as the squamosal on both sides articulates with the frontal. The left occipital condyle is wider and longer, the right narrower and shorter, and both anterior condyloid holes are undivided, both posteriors wanting. The stylohyals are short, while in No. 1 they are very long, ankylosed, and the jugular holes are only imperfectly bridged. The upper band of the pterygo-spinous ligament is ossified, and the scaphoid fossa is small. The nasal bones are typically flattened and nearly of equal width throughout; the lachrymal has a very short ethmoidal suture, 8 mm. long, and a slight trace of a superior process.

The scapular index of No. 1 is ·73°, of No. 2 is ·71. In No. 1 the clavicles are markedly unsymmetrical, the right being 150 mm., the left 132 mm. long. The left humerus has an intercondyloid perforation. The tibiæ are nearly platycnemic; and each femur has a well-marked tuberculum colli anterior.

The sacrum is short and curved, somewhat like that of a small female, and the first rib articulated with the seventh cervical on the left. The atlas has a complete (left) and an incomplete (right) bridge on the posterior arch over the vertebral artery.

No. 2 is a much more massive skeleton, with two small ribs on the first lumbar vertebræ, a perfectly detached first sacral vertebræ; the sacrum with a strong downly-directed spur on its lower left side. The ossa innominata were enormously solid; when dried, one weighed 1lb., the other ¾lb. All the bones have their crests much exaggerated.

The femur has a strong supra-condyloid spur; the calcaneum projects an inch and three-quarters behind the tibia.

The humeri are very much flattened at their lower end, and the forearm bones are markedly unsymmetrical on the two sides.

The special points of interest in these two skeletons are: 1st, their respective intermembral lengths; 2nd, their general cranial characters.

APPENDIX A.

TABLE OF MEASUREMENTS.

	No. 1.	No. 2.
Right Radius, greatest length,	26·3	28·1
Left Radius, ,, ,,	25·5	27·2
Right Ulna, ,, ,,	29·0	29·7
Left Ulna, ,, ,,	27·9	29·4
Right Humerus, ,, ,,	31·3	33·5
Left Humerus, ,, ,,	30·7	33·5
Right Clavicle, ,, ,,	15·0	15·5
Left Clavicle, ,, ,,	13·2	15·5
Femur, ,, ,,	46·0	47·0
Tibia, ,, ,,	38·0	42·0
Fibula, ,, ,,	38·0	40·0

APPENDIX B.

TABLE OF INDICES.

	No. 1.	No. 2.
Intermembral (right),	71·0	71·0
Intermembral (left),	69·0	70·0
Femoro-tibial,	82·6	89·3
Tibio Fibular,	100·0	95·2
Humero-radial (right),	84·0	85·1
Humero-radial (left),	83·0	82·4
Humero-ulnar (right),	95·0	89·0
Humero-ulnar (left),	90·0	90·0
Radio-ulnar (right),	90·0	91·0
Radio-ulnar (left),	94·0	92·0
Altitudinal Cephalic,	78·0	74·0
Latitudinal Cephalic,	73·5	72·3
Orbital,	86·8	81·7
Nasal,	50·0	57·0
Scapular,	73·0	71·0

LVIII.—THREE YEARS' OBSERVATIONS OF THE TIDES AT LIVERPOOL (FLEETWOOD). By the REV. JAMES PEARSON, M.A., F.R.A.S., late Scholar (15th Wrangler) of Trinity College, Cambridge, Vicar of Fleetwood.

[Read, December 13, 1880.]

IT is now two years ago since I last had the honour of addressing the Academy on the above subject, and it is ten years at least since I first began a close application to the study of it. During all this interval I have been making a continuous system of observations, and have compared them with the results of theory, so as to form an exact opinion as to whether the method of computation which my own investigation led me to adopt was true to nature. It is a subject which becomes more fascinating the more it is indulged in. Few care to give to it the attention it deserves, and fewer still have the opportunity of noting the effect of barometric changes and atmospheric gradients so as to eliminate these disturbing causes from the general effects. Mrs. Somerville designated the state of the theory of the tides in her time as "a reproach to science"; and even Dr. Whewell, in his "History of the Inductive Sciences," complains of want of success. Under those circumstances there is every encouragement to persevere in the study. Like an unploughed field, it demands cultivation, and the more because so few care to work in it. Although recently a renewed effort has been made, and a fresh theory, based on a Harmonic Analysis, has been adopted, aided by a complicated and expensive machine which is to facilitate calculation, yet no practical tables have been forthcoming which may be submitted to the test of experiment, so far at least as one of the most important seaports of our country is concerned, viz., the Port of Liverpool. At this station we have two superimposed tides of 27½ feet mean range arriving at the same instant, or nearly so; and the force of gravitation may be as plainly seen in action as the movement of the machinery of a watch is discerned by noticing the motion of the seconds-hand. Hitherto the only tide-tables put into circulation have been (1) those published in the Isle of Man, (2) those originated by the Rev. George Holden, M.A., and printed in Liverpool, and (3) the Admiralty tables issued in London. The first are of more recent date than the second, but the mode of computation adopted in producing them is kept an inviolable secret. On this point Dr. Whewell writes as follows ("History of the Inductive Sciences," vol. ii., p. 255):—"Art, in this instance, having cast off her legitimate subordination to Science, or rather, being deprived of the guidance which it was the duty of Science to afford, resumed her ancient practices of exclusiveness and mystery. Liverpool, London, and other places, had their tide-tables, constructed by undivulged methods, which methods, in some instances at least,

were handed down from father to son, for several generations, as a family possession; and the publication of new tables, accompanied by a statement of the mode of calculation, was resented as an infringement of the rights of property." I am not aware that the mystery has even yet been divulged, though I am sure much progress has been made towards its solution by an independent inquiry.

The first object of such an inquiry is to ascertain the laws which regulate what is technically called the "diurnal inequality." This it is which causes the spring-tides sometimes to increase successively by irregular steps, each being alternately greater and less than the one preceding, and sometimes to succeed each other by continuous increments of height. This, though due to the changes of the moon's and sun's declination, as its ultimate cause, is much dependent on the configuration of land and water in the regions through which the tidal wave has to traverse; and Dr. Whewell's statement may still be safely endorsed—"Although Laplace's conjecture, that in the moving fluid the motions must have a periodicity corresponding to that of the forces, may in some cases of the problem be verified, this cannot be done in the actual case where the revolving motion of the ocean is prevented by the intrusion of tracts of land, running nearly from pole to pole." He adds: "I am not aware that for such a case anything has been done to bring the hydrodynamical theory of oceanic tides into agreement with observation."

Now it is precisely for the object of bringing theory into agreement with observation that the method has been devised to which I wish to call attention—a method which has been embodied for several years past in the Admiralty Tables. It is based on a modification of Sir John Lubbock's Tables, and rests on the equilibrium theory of Bernouilli, and it embodies the law which regulates the diurnal inequality. I propose to submit the method to the same test to which all the other consequences of gravitation have been submitted, viz.—the calculation of tables, and the continued and orderly comparison of these with observation. In order to do this satisfactorily, we shall select a period of time when settled weather indicates that atmospheric disturbing causes have had a minimum effect, the error from accuracy being in each case pointed out, and a note being made of the atmospheric conditions.

Our first record will show ten successive tides in February, 1878:—

Date.		Calculation.	Observation.	Error.	Barom., Wind, &c.
1878.		ft. in.	ft. in.	in.	
Feb. 13,	M.	19·7	19·7	0	29·9, S., slight.
	E.	20·3	20·2	− 1	30·0, W., ,,
14,	M.	21·2	21·0	− 2	,, S., ,,
	E.	21·11	22·2	+ 3	,, ,, ,,
15,	M.	23·8	23·9	+ 1	,, ,, ,,
	E.	24·6	24·8	+ 2	30·1, S.W., fresh.
16,	M.	25·10	25·8	− 2	30·2, ,, ,,
	E.	26·6	26·4	− 2	,, S., slight.
17,	M.	27·11	28·1	+ 2	30·1, S.W., fresh.
	E.	28·0	28·8	+ 8	30·0, ,, strong.
18,	M.	29·4	29·6	+ 2	,, ,, abating.
	E.	—	—	—	

Our next comparisons shall be taken from the month of April in the same year :—

Date.		Calculation.	Observation.	Error.	Barom., Wind, &c.
1878.		ft. in.	ft. in.	in.	
Apr. 8,	M.	23·3	23·6	+ 3	30·1, S.S.W., strong.
	E.	22·10	22·10	0	,, S.S.E., ,,
9,	M.	22·2	21·10	− 4	30·2, ,, ,,
	E.	21·6	21·1	− 5	,, E., ,,
10,	M.	20·8	20·11	− 3	,, ,, fresh.
	E.	19·11	19·11	0	,, ,, slight.
11,	M.	19·11	19·11	0	,, S.E., ,,
	E.	19·8	19·6	− 2	,, ,, S., ,,
12,	M.	20·2	19·11	− 3	,, S.S.E., ,,
	E.	20·10	20·8	− 2	,, ,, calm.
13,	M.	22·1	22·2	+ 1	30·1, S., ,,
	E.	22·11	23·3	+ 4	30·0, S.W., signal out.
14,	M.	24·5	24·5	0	,, ,, slight.
	E.	24·11	25·3	+ 4	,, S., ,,
15,	M.	26·6	26·7	+ 1	30·1, W.S.W., fresh.
	E.	27·0	27·0	0	,, ,, calm.
	M.	28·5	28·9	+ 4	,, S., slight.
	E.	28·2	28·3	+ 1	29·9, S.W., ,,
	M.	29·1	29·0	− 1	,, W., ,,
	E.	28·9	28·7	− 2	,, W.S.W., ,,
	M.	29·1	29·0	− 1	,, W., ,,
	E.	—	—	—	

ths of August and September, 1880, shall supply our
ons:—

	Calculation.	Observation.	Error.	Barom., Wind, &c.
30.	ft. in.	ft. in.	in.	
24, M.	27·8	27·6	− 2	30·4, N.W., slight.
E.	25·6	25·6	0	,, N., ,,
, M.	26·1	26·0	− 1	,, ,, ,,
E.	24·0	24·3	+ 3	30·3, S., Bar. falling.
26, M.	24·2	24·3	+ 1	30·2, ,, slight.
E.	22·6	22·10	+ 4	,, S.W., ,,
27, M.	22·7	22·4	− 3	30·3, calm.
E.	20·10	21·1	+ 3	30·4, N.W., fresh.
28, M.	20·5	20·4	− 1	30·5, ,, slight.
E.	19·2	19·7	+ 5	,, E., ,,
29, M.	18·8	18·9	+ 1	30·4, N.E., ,,
E.	18·7	18·4	− 3	30·3, ,, fresh breeze.
30, M.	18·8	18·8	0	30·2, E., slight.
E.	19·4	19·9	+ 5	,, S., ,,
31, M.	19·6	19·7	+ 1	30·3, calm.
E.	20·10	21·3	+ 5	30·4, S., slight.
Sept. 1, M.	21·1	21·6	+ 5	,, S.S.W., fresh; signal out.
E.	22·6	22·7	+ 1	30·5., S., slight.
2, M.	22·10	22·7	− 3	30·6., S.W., slight.
E.	24·3	24·2	− 1	,, ,, ,,
3, M.	24·4	24·0	− 4	30·5, N.W.W., slight.
E.	25·8	25·5	− 3	30·4, calm.
4, M.	25·6	25·6	0	30·3, S.S.W., calm.
E.	26·11	26·10	− 1	30·2, S.W., slight.
5, M.	26·5	26·6	+ 1	,, S.S.W., gusty.
E.	27·9	27·4	− 5	,, depression approaching.

In conclusion, it is only necessary to observe how important it is not only to ascertain the normal height of the tide. but also the amount of the correction to be applied in consequence of atmospheric disturbances. Where so many causes are combined, nothing but patient experience and judgment will effect this. The most likely means of obtaining an accurate prediction is to notice the successive changes of sea-level from day to day, and add or subtract accordingly.

LIX.—RESEARCHES ON ANNUAL PARALLAX, MADE AT DUNSINK. By ROBERT S. BALL, LL.D., F.R.S., Royal Astronomer of Ireland.

[Read, January 10, 1881.]

IN the following Paper I give a brief sketch of some of the observations which have been made at Dunsink during the last two or three years. The full details will appear in the publications of the Observatory, Part V. Some of the results have already been recorded in the Journals which are more specially devoted to Astronomy (see *Monthly Notices*, R.A.S., Nov. 1880, Jan. 1881, and *Urania*, No. 1). The three objects to which I wish to draw attention are the stars known as 61 Cygni, P III 242, and Groombridge 1618.

(61 CYGNI).

In 1838 Bessel commenced a series of measures from the central point between the two components of 61 Cygni to the two other stars

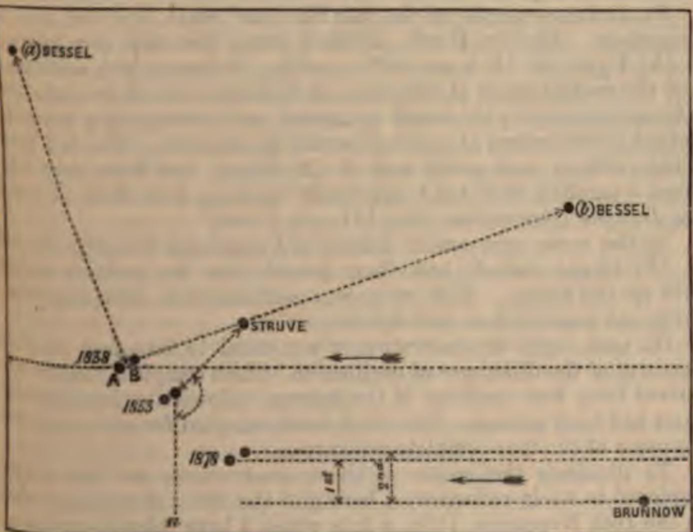

Fig. 1.—61 Cygni and Comparison Stars.

a and *b* (see Fig. 1). *a* is a star of the 8·8 mag., and is known as BD + 37°, 4173; while *b* is a star of the 8·6 mag., known as BD + 37°,

4179. The result of a most elaborate series of measures made with the heliometer gave for 61 Cygni a parallax of about one-third of a second.

Fifteen years later, Struve undertook a new determination of the parallax of 61 Cygni, which had by that time moved into the position marked 1853, Fig. 1. The comparison star employed by Struve was of the 9·4 mag., BD + 38°, 4345. He employed measures of the distance and position angle of 61 (B) Cyg. from the comparison star. The result of Struve's labours seemed to indicate that the parallax of 61 Cygni was half a second.

Considerable doubt existed as to which result was the correct one. Auwers,[1] on a discussion of the whole question, was inclined to agree with Struve, and it was with the view of settling the difference that Dr. Brünnow commenced the work. It had, however, been but little more than commenced when Dr. Brünnow resigned his position at Dunsink, and on me, as his successor, devolved the task of continuing and completing the work. A first instalment of the Observations, and a discussion of the result, has been already given in Part III., *Dunsink Observations*. I now give a further instalment, completing the observations made by myself. The final discussion of the entire series, which amalgamates Dr. Brünnow's work and my own, must be postponed until the publication of Part V. of *Dunsink Observations*.

Dr. Brünnow employed the star BD + 38°, 4351, 9·5 mag., for the comparison. On 31st March, 1878, I found that this star followed 61 (A) Cygni in 51ˢ·5 and 66″·5, north. Brünnow had ascertained that the measurement of difference of declination could be made with extreme accuracy by the South equatorial, and consequently it was the method of differences of declination that he employed. The first series of observations were made with 61 (A) Cygni, and from them I deduced a parallax of 0″·4654, practically agreeing with Struve's result. See *Dunsink Observations*, Part III., pp. 16–40.

In the series now under discussion I employed the *following* star 61 (B) Cygni, which had then moved into the position marked 1878 on the figure.. This series was commenced on 18th September, 1878, and concluded on 2nd October, 1879.

On each night of observation it was usual to take four complete measures of the difference of declination. Each complete measure was derived from four readings of the screws, followed by four after the wires had been crossed. The final result adopted for each night was the mean of the four complete measures.

To illustrate the nature of these observations, and the method employed in their reduction, I here give the series of measures taken on the 16th November, 1878, a date which I have selected at random.

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[1] *Abhandlungen* der Akademie zu Berlin, 1868.

Micrometric Measurements of the Difference of Declination between 61 (B) Cygni *and* BD + 38°, 4351, *on* 16*th November*, 1878.

Screw I.	Screw II.	Screw I.	Screw II.	Screw I.	Screw II.	Screw I.	Screw II.
63698	40627	55783	32139	64318	40047	55599	32446
63753	40598	55857	32134	64163	40177	55562	32506
63791	40537	55902	32063	64175	40237	55501	32549
63823	40537	55921	32074	64097	40257	55483	32633
55639	32356	64217	40184	55906	32143	63557	40863
55666	32353	64215	40142	55697	32293	63293	41103
55732	32268	64202	40113	55716	32303	63267	41088
55753	32262	64213	40095	55708	32348	63154	41228

Each of these eight columns had first to be reduced to seconds. This is accomplished by adding together the four larger numbers in each column, and subtracting from the result the sum of the four smaller numbers. *E. g.* for the first column this result is 32·275. This has to be multiplied by one-eighth of the value of the micrometer Screw I., at the temperature of the instrument (39°·9). The result thus found is 36″·292. In a similar manner the movement of Screw II. in the second column gives 37″·224. Thus the first set of measures on the night in question gives for the apparent total distance the result 73″·516. This must, however, receive a correction of + 0″·026 on account of refraction, and of – 0″·031 on account of reduction for aberration, precession, and nutation, so that the final result is 73″·511. In a similar manner we have for each of the other sets of observations on the night in question 73″·705, 73″·539, 73″·453. The mean of the whole four is 73″·552, which is accordingly taken as the final result of the observations for this one night.

In many cases the number of complete measures was less than four, so it has been found convenient, when estimating the weight attached to each night's work, to use the number of complete measures which have been obtained. Thus, for the night just considered, the weight is taken as 4.

The following Table contains the mean results of the observations on the several nights which are included in the present series :—

Mean Results of the Observations of the Difference in Declination between 61 (B) Cygni *and* BD + 38°, 4351, *reduced for Refraction and Reduction.*

Date.	Difference.	Date.	Difference.	Date.	Difference.
1878.		1879.		1879.	
Sept. 18,	73″·657	Nov. 17,	73″·609	April 30,	72″·117
,, 20,	73 ·633	,, 21,	73 ·507	May 4,	72 ·229
,, 23,	73 ·579	,, 25.	73 ·615	,, 8,	71 ·907
,, 25,	73 ·613	,, 28,	73 ·437	,, 15,	71 ·602
Oct. 13,	73 ·520	Dec. 1,	73 ·554	,, 22,	71 ·640
,, 24,	73 ·698	,, 5,	73 ·436	June 10,	71 ·530
,, 25,	73 ·528	,, 8,	73 ·442	,, 15,	71 ·345
,, 28,	73 ·739	,, 30,	73 ·268	,, 28,	71 ·169
,, 29,	73 ·537	1879. Jan. 8,	73 ·400	July 26,	70 ·853
,, 31,	73 ·707	,, 15,	73 ·370	Sept. 17,	70 ·424
Nov. 1,	73 ·802	,, 18,	73 ·325	Oct. 2,	70 ·816
,, 8,	73 ·633	April 10,	72 ·512		
,, 16,	73 ·552	,, 16,	72 ·348		

A glance at these results exhibits, in a conspicuous manner, the large proper motion of 61 (B) Cygni relatively to the star which has been chosen for comparison. To clear the observations from the grosser part of the effects of proper motion, it became necessary to adopt an approximate value of the relative annual proper motion in declination. The former series of observations had conclusively established the fact that the comparison star is not affected by any considerable proper motion. I therefore felt warranted in assuming Argelander's value of the absolute proper motion of 61 B Cygni in declination as approximately the relative proper motion. The value in question is + 3″·016 (*Positiones Mediæ*, p. 27).

The mean epoch of the entire series of observations is 1879·069. The mean value of the observed differences of declination is 72″·85549. The assumed epoch is 1879·0, whence, applying a correction of + ·20865 for proper motion, we have as the adopted mean difference of declinations at the epoch 73″·06414.

The equations of condition are now formed in the usual manner.

The true mean distance at the epoch is assumed to be $73''{\cdot}06414 - x$; the true value of the proper motion in declination is assumed to be $3''{\cdot}016 + x'$; the correction to be applied to an observed difference of declination for parallax ϖ is $-[9{\cdot}92229]\cos(\odot - 121^\circ\ 39')\,R\varpi$. The correction to be applied for a possible difference κ between the coefficients of aberration of the two stars is $-[9{\cdot}92229]\sin(\odot - 121^\circ\ 39')\,\kappa$.

Solving the equations, I obtain

$$x = +0''{\cdot}0227 \pm 0''{\cdot}0194,$$
$$x' = -0''{\cdot}0878 \pm 0''{\cdot}0705,$$
$$\varpi = +0''{\cdot}4676 \pm 0''{\cdot}0321,$$
$$\kappa = +0''{\cdot}0719 \pm 0''{\cdot}0314.$$

The sum of the squares of the absolute terms is 6·172, while the sum of the squares of the residuals is but 1·223, the weights being of course taken into account in each case.

The probable error of one observation is $\pm 0''{\cdot}1298$, whence the

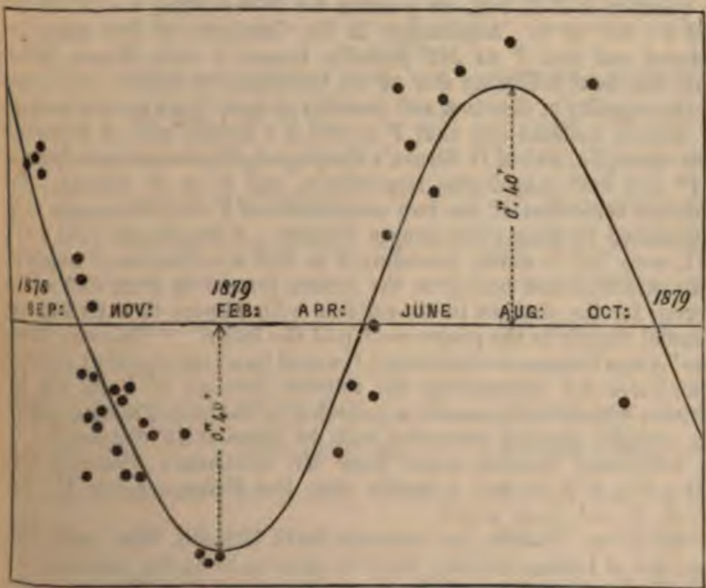

Fig. 2.—Parallax in Declination of 61 (B) Cygni. Ordinates indicate Parallax of $0''{\cdot}47$. Dots indicate Observations.

probable error of the mean of four observations which form a complete series for one night is $\pm 0''{\cdot}0649$.

The agreement of the present parallax of $0''{\cdot}4676$ with that of

0″·4654, found by the former series, is very satisfactory. The accordance is indeed so close that there can be no doubt it is to some extent due to the chapter of accidents. These investigations confirm the supposition that the annual parallax of 61 Cygni is nearer the half second found by Struve than the third of a second found by Bessel.

In order to show the degree of accuracy which can be expected in such observations, I give a diagram (Fig. 2) which represents the present series of observations on the assumption of a parallax of 0″·4676. The effect of such a parallax on the difference of declinations cannot exceed 0″·40. The dots denote the observations, and the curve gives the calculated effect of parallax.

Though some of the discrepancies seem large, relatively to the total amount to be measured, yet the greatest divergence of the observation from the curve is not more than the angle subtended by a penny-piece at the distance of fifteen or twenty miles.

(P III 242.)

In the *Monthly Notices*, vol. xx. p. 8, is a Paper by O. Struve, "On a star which would be suitable for a parallax series." The star in question is P III 242, its position for 1879·0 being $\alpha = 3^h\ 59^m\ 30^s$, and $\delta = 37°\ 45'·3$. Argelander, in his Catalogue of 560 stars, had pointed out that P III 242 probably formed a wide Binary system with the next following star of his Catalogue 50 Persei, on account of the equality in direction and quantity of their large proper motions.

Struve remarks also that P III 242 is a double star of Herschel's first class (No. 531 of O. Struve's Catalogue), the components being of 6·7[th] and 8·9[th] magnitudes respectively, and 3″ or 4″ distant. The physical correction of the two components of P III 242 appears to be established by their equal proper motions. A fourth star (BD + 37°, 877, mag. 7·8) is south, preceding P III 242 at a distance of nearly 4′. This star does not belong to the system formed by P III 242 and 50 Persei, for the changes in its position with respect to P III 242 correspond exactly to the proper motion of the latter. "This star, therefore" (says Struve, in conclusion) "would be a very qualified object of comparison for determining the relative parallax of P III 242, for which a considerable amount is indicated by the proper motion, and by the probable physical connexion with 50 Persei at 15′ distance."

Additional interest arises from Mr. Burnham's discovery that BD + 37°, 877, is also a double star, the distance being 1″. See *M. A. S.*, vol. XLIV. p. 158.

So far as I know, no measures have hitherto been made with the view of testing whether Struve's surmise as to the existence of a parallax for P III 242 could be substantiated. I therefore commenced a series of observations in January, 1879, of the distance and position of the comparison star which Struve suggested, from the larger star of the pair P III 242.

In an important feature, however, the observations now to be discussed are very different from those which had previously been made

with our micrometer. The distance in this was no less than 237″ ±, which is greatly in excess of the distances measured in the regular series of parallax observations contained in our previous publications. Had there been any suitable companion star nearer to P III 242, I should certainly have preferred it, for the distance 237″ is too great to be measured by our micrometer with the accuracy which can be attained when the distance is only about one or two minutes. From this cause the results of the observations are not so satisfactory as I would wish, though they are quite sufficient to show that P III 242 has no considerable parallax.

The following are the observations which I have made of the distance and position corrected for refraction, and reduced to the mean places of the stars at the epoch 1879·0 :—

P III 242.

Distance and Position of BD + 37°, 877 *from* P III 242.

Date.	Distance.	Position.	Date.	Distance.	Position.
1879.			1879.		
Jan. 11,	237″·558	207° 17′·35	Oct. 5,	237″·203	207° 17′·28
Feb. 7,	237 ·529	207 23 ·47	„ 17,	237 ·497	207 16 ·14
„ 19,	237 ·074	207 13 ·16	„ 25,	237 ·315	207 17 ·12
„ 22,	237 ·174	207 16 ·04	„ 25,	237 ·049	207 22 ·83
„ 23,	237 ·695	207 10 ·25	Nov. 1,	236 ·965	207 8 ·40
„ 25,	237 ·348	207 16 ·96	„ 2,	237 ·305	207 17 ·66
March 1,	237 ·220	207 9 ·08	„ 8,	237 ·041	207 19 ·72
„ 19,	237 ·605	207 15 ·99	„ 8,	237 ·423	207 21 ·57
April 4,	237 ·422	207 9 ·27	„ 11,	237 ·588	207 12 ·86
„ 6,	—	207 14 ·00	Dec. 3,	237 ·647	206 59 ·53
„ 10,	237 ·495	207 15 ·66	„ 5,	237 ·186	207 5 ·91
Aug. 14,	237 ·268	207 19 ·18	„ 17,	237 ·587	207 25 ·42
„ 22,	236 ·973	207 8 ·47	„ 18,	237 ·215	207 29 ·27
„ 23,	237 ·177	207 12 ·83	„ 24,	237 ·130	207 22 ·88
Sept. 17,	237 ·242	207 16 ·28	1880.		
Oct. 4,	237 ·151	207 20 ·24	Jan. 9,	236 ·715	207 20 ·66

According to O. Struve (*loc. cit.*), the annual proper motion in right ascension is $+0^s{\cdot}0167$, and the declination $-0''{\cdot}152$. It hence appears that the arc moved over in one year by P III 242 is $0''{\cdot}2497$, while the position angle of the star, in the position it will occupy next year, measured from the present position, is $127^\circ{\cdot}5$. The correction to be applied to the observed distance, in order to reduce the observed distance to that between the places at the epoch, is $0''{\cdot}04407$ per annum, while the corresponding correction to the observed position angle is $-3'{\cdot}565$, or in arc $-0''{\cdot}2457$.

The adopted mean distance at the epoch is $237''{\cdot}320$, and the adopted mean position is $207^\circ\ 13'{\cdot}86$.

From the usual formulæ it is found that when $\odot$ is the sun's longitude, R the sun's radius vector, and π the annual parallax of P III 242, the correction to be applied to the observed distance to clear it from the effects of parallax is

$$-[9{\cdot}82787]\ \varpi R \cos(\odot - 174^\circ\ 56'\ 0''),$$

while the corresponding correction for the observed position angle is

$$-[9{\cdot}90007]\ \varpi R \cos(\odot - 142^\circ\ 8'\ 29'').$$

Assuming that x is the correction to be applied to the annual mean distance, while x' is the correction to the assumed value of the proper motion in distance, and κ is a probable difference in the coefficients of aberration of the stars, then we have from the observations of the distance the usual equations of condition.

Solving these, we deduce in the usual way

$$x = -0''{\cdot}1459 \pm 0''{\cdot}08,$$

$$x' = +0''{\cdot}3009 \pm 0''{\cdot}15,$$

$$\varpi = +0''{\cdot}0163 \pm 0''{\cdot}09,$$

$$\kappa = +0''{\cdot}1405 \pm 0''{\cdot}12.$$

The sum of the squares of the residuals is $1{\cdot}2732$, from which the probable error of one complete observation is $\pm 0''{\cdot}15$. The sum of the squares of the absolute terms is $1{\cdot}4638$.

We next proceed to form the equations of condition from the observations of the position angle. In a complete series of measures, four observations of the parallel and four of the position angle have been made. Owing to the great distance of the stars, the measurements of the position angle (estimated in arc) are not very satisfactory; and on two occasions (3rd December and 5th December, 1879) the discrepancies have attained to very undesirable dimensions. The residual on 3rd December is no less than $-1''{\cdot}332$, but only a weight of one-half attaches to this result because it was based on but two observations of the parallel and two of the position. The notes at the time of

observation are, "snow and severe frost; low and hazy, but tolerably steady." On the next night of observation, December 5th, the number of observations was complete, and they were fairly accordant: the notes at the time record, "good definition; thaw; occasional clouds:" the residual on this occasion is $-0''\cdot895$. It will be noticed that these observations occur at dates when the parallax produces but very little effect, the coefficient being $+\cdot2536$ on the first occasion, and $+\cdot2801$ on the second. From these we obtain

$$x = +0''\cdot0185 \pm 0''\cdot14,$$

$$x' = +0''\cdot0076 \pm 0''\cdot27,$$

$$\varpi = -0''\cdot1371 \pm 0''\cdot11,$$

$$\kappa = +0''\cdot1420 \pm 0''\cdot18.$$

The sum of the squares of the absolute terms of the equations is $+4\cdot3105$, and the sum of the squares of the residuals is $+4\cdot1077$, from whence the probable error in an arc of one complete observation of the position angle is

$$\pm 0''\cdot263$$

If we combine the two values of the parallax, making due allowance for the weights, we obtain, as the final result of this series of observations,

$$\varpi = -0''\cdot045 \pm 0\cdot070.$$

If this result were to be strictly interpreted, it would mean that the comparison star was actually the more distant of the two. Observing, however, that the probable error is greater than the parallax itself, it would seem unsafe to draw any conclusion from these observations, save that the difference between the parallaxes of P III 242 and BD $+37°$ 877 is too small to be measured with accuracy.

GROOMBRIDGE 1618.

This star is No. 89 of Argelander's list of stars, with large proper motion (Bonn, *Obs.*, vol. vii. p. 69). It is $+50°$, 1725 in the *Duchmusterung*, where its magnitude is given as 6·8. The position of the star at the epoch 1878·0 is found from meridian observations at Washington in 1871, and Radcliffe observations in 1859, to be R. A. $= 10^h\ 3^m\ 53^s\cdot73$, $\delta = 50°\ 4'\ 13''\cdot9$, allowance having been made for the proper motions.

According to Argelander (*l. c.* p. 110) the proper motion in R. A. is $-0^s\cdot1390$, and in Decl. $-0''\cdot501$. This corresponds to an arcual proper motion of $1''\cdot429$ per annum, the position angle being 249° 29′, *i. e.*, this is the position angle of the place of the star next year from the present place.

The distance and position of the adjacent star $+50°$, 1724 (8·8 mag.) has been measured with the view of ascertaining the parallax

of Gr. 1618. It will at the outset be of importance to show tha comparison star has not a proper motion comparable in magn with that of Gr. 1618.

This will appear most clearly by a comparison of the recent o vations with those made by Argelander on March 21st, 1843, as re in Argelander-Oeltzen to the epoch 1842·0. From an approxi reduction of my observations I conclude that at the epoch 1878· distance of + 50°, 1724 from Gr. 1618 is 198″·1, and the position is 201° 42′·8. From this I find

$$\Delta\alpha = 7^s{\cdot}603,$$

$$\Delta\delta = 184''{\cdot}1\,;$$

but from Argelander-Oeltzen, we have

$$\Delta\alpha = 12^s{\cdot}4,$$

$$\Delta\delta = 203''{\cdot}9.$$

We apply to these differences the annual proper motion of Gr. 1 viz. $-0^s{\cdot}1390$ in R. A. and $-0''{\cdot}501$ in Decl. During the thirty years that have elapsed since Argelander's observations the correc will amount to $-4^s{\cdot}87$ and $-17''{\cdot}5$, respectively. We thus fin the values in 1878

$$\Delta\alpha = 7^s{\cdot}5,$$

$$\Delta\delta = 186''{\cdot}4.$$

It is therefore evident that + 50°, 1724 cannot have a proper tion which even in thirty-five years amounts to much more than 0 R. A., or 2″·3 in Declination. Compared with the large proper m of Gr. 1618 these quantities are inappreciable. We may, there conclude as a first approximation that the absolute proper m assigned by Argelander to Gr. 1618 coincides with its proper m relatively to the comparison star + 50°, 1724.

The annual decrement of the distance from Gr. 1618 to + 50°, 1 in consequence of the proper motion of the former, is 0″·9579. position angle decreases for the same reason at the rate of 18 annually.

In the first series of observations now to be discussed, measurem were made on fifty-five nights both of distance and position. I present Paper the measurements of the distance alone are discuss

The following Table contains the observations of the distance, rected in the usual manner, for the effects of refraction and tem ture of the micrometer screw, and reduced to the epoch 1878·0. corrections for proper motion have, however, not yet been applied

GROOMBRIDGE 1618, I.

Corrected Distance of + 50°, 1724 *from* Gr. 1618.

Date.	Distance.	Date.	Distance.	Date.	Distance.
1878.		1878.		1878.	
March 4,	198″·381	April 24,	198″·507	Sept. 25,	198″·029
„ 13,	198 ·542	„ 27,	198 ·261	Oct. 24,	197 ·830
„ 13,	198 ·459	May [illegible]	[illegible]	[illegible] 28,	198 ·195
„ 15,	198 ·370	„ [illegible]	[illegible]	[illegible] 1,	197 ·858
„ 18,	198 ·484	„ [illegible]	[illegible]	[illegible] 8,	197 ·970
„ 18,	198 ·581	„ 1[illegible]	[illegible]	[illegible] 17,	197 ·799
„ 21,	198 ·537	„ 2[illegible]	[illegible]	[illegible] 19,	197 ·949
„ 21,	198 ·499	„ 2[illegible]	[illegible]	[illegible] 25,	198 ·059
„ 22,	198 ·450	„ 2[illegible]	[illegible]	[illegible] 28,	198 ·105
„ 24,	198 ·783	July [illegible]	[illegible]	[illegible] 1,	198 ·303
„ 24,	198 ·753	„ [illegible]	[illegible]	„ 5,	198 ·063
„ 25,	198 ·484	„ [illegible]	[illegible]	„ 8,	198 ·337
„ 29,	198 ·493	„ 12,	197 ·806	1879. Jan. 8,	198 ·088
„ 29,	198 ·605	„ 21,	197 ·743	Feb. 5,	197 ·958
„ 31,	198 ·445	„ 28,	197 ·795	„ 22,	197 ·993
„ 31,	198 ·460	„ 30,	197 ·999	„ 25,	198 ·142
April 1,	198 ·537	„ 31,	197 ·751	„ 28,	198 ·184
„ 1,	198 ·493	August 2,	197 ·892	March 19,	198 ·213
„ 6,	198 ·461	„ 10,	198 ·047	„ 31,	197 ·819
„ 17,	198 ·353	Sept. 20,	197 ·869	April 2,	197 ·578
„ 21,	198 ·415	„ 23,	198 ·221		

From these, I conclude in the usual manner,

$$x = -\,0''\cdot1621 \pm \cdot05$$
$$x' = +\,0''\cdot1534 \pm \cdot07$$
$$\varpi = +\,0''\cdot3472 \pm \cdot05$$
$$\kappa = -\,0''\cdot2890 \pm \cdot06$$

able error of one complete observation is ± ·15.
of the squares $(nn) = 3{\cdot}537$.
of the squares $(vv) = 2{\cdot}935$.
lt of the observations is therefore to indicate a parallax of ird of a second for Gr. 1618. Though the probable error t is only 0″·05, yet there were certain features which e to require further examination. The signs of the resi- if some systematic irregularity had affected the measures. lue of the unknown κ seems also somewhat improbable. substitution of the values for the unknowns only abates the sum of ires of the absolute terms from 3·5373 to 2·935. I therefore de- commence another series of observations, in the hope that the e already obtained would ensure a better result.

GROOMBRIDGE 1618, II.

Corrected Distances of + 50°, 1724 *from* Gr. 1618.

Date.	Distance.	Date.	Distance.	Date.	Distance.
1879.		1880.		1880.	
Aug. 14,	197″·187	Mar. 12,	196″·473	April 25,	196″·629
,, 23,	196 ·846	,, 15,	196 ·398	,, 27,	196 ·589
Oct. 28,	197 ·184	,, 18,	196 ·170	May 6,	196 ·432
Nov. 1,	196 ·935	,, 19,	196 ·577	,, 7,	196 ·255
,, 11,	197 ·079	,, 19,	196 ·524	,, 8,	196 ·317
,, 13,	196 ·841	,, 20,	196 ·862	,, 13,	196 ·466
,, 30,	197 ·228	,, 21,	196 ·557	,, 15,	196 ·319
Dec. 4,	197 ·056	,, 21,	196 ·489	,, 16,	196 ·577
,, 10,	197 ·177	,, 22,	196 ·545	July 15,	196 ·191
,, 17,	196 ·970	,, 22,	196 ·626	,, 16,	195 ·807
,, 18,	196 ·817	,, 31,	196 ·924	,, 20,	196 ·009
1880. Jan. 9,	196 ·985	April 6,	196 ·452	,, 21,	195 ·748
,, 21,	196 ·961	,, 8,	196 ·583	,, 21,	195 ·852
Feb. 4,	197 ·077	,, 22,	196 ·517	,, 29,	195 ·757
,, 5,	196 ·985	,, 24,	196 ·583		

From these we find the following values:—

$$x = -0''\cdot3532 \pm \cdot133,$$

$$x' = +0''\cdot3222 \pm \cdot116,$$

$$\varpi = +0''\cdot3196 \pm \cdot052,$$

$$\kappa = -0''\cdot0422 \pm \cdot066.$$

The probable error of one observation is ± ·119.
The sum of the squares $(nn) = 2\cdot330$.
The sum of the squares $(vv) = 1\cdot255$.

These observations are free from the features which appeared to me to be objectionable in the former series. On the other hand, it is to be observed that the corrections to the proper motion and to the annual mean distance now attain considerable amounts. This is, I believe, partly due to the choice of an epoch which is more than a year from the mean date of the observations. To examine the plausibility of these corrections I have combined the results of the two series of observations, taking account of their probable errors. I thus find

$$x = -0''.1858 \pm \cdot047,$$

$$x' = +0''\cdot1985 \pm \cdot060,$$

$$\varpi = +0''\cdot3339 \pm \cdot036,$$

$$\kappa = -0''\cdot1774 \pm \cdot044.$$

These results do not appear to be at all improbable. A positive correction to the proper motion is indeed indicated by the adopted mean distances at the epochs of 1878 and 1879. These are, respectively, 190·7608 and 197·7308. This corresponds to a proper motion in the distance of somewhat over a second per annum, while the assumed proper motion is somewhat less than a second. Nearly half of the value of x' is thus accounted for.

I believe that these observations render the existence of a parallax of about one-third of a second tolerably certain. It will not, however, be possible to determine the parallax definitively until further investigations have been made. Measurements of the position angle of the comparison star from Gr. 1618 are very well adapted for this purpose. Indeed, the parallax has a much larger effect upon the position angle than it has upon the distance. I have made such measurements at the same time as the measurements of distance which are here discussed. These observations are not yet ready for publication. I may, however, say that though some difficulties have been met with, yet the position angle observations, as a whole, tend to confirm the fact that Gr. 1618 has a parallax sufficiently large to entitle it to a place among the sun's nearest neighbours.

LX.—Report on the Flora of the Blasket Islands, Co. Kerry. By Richard M. Barrington, M.A., LL.B.

[Read, February 14, 1881.]

The group of islands known as the Blaskets lie to the west of Dingle promontory, Co. Kerry, and their geology and position show that they are but a prolongation of its ridge. They are interesting, as being the most westerly land in Europe, if we except the Azores. They lie west of 10° 30′ west longitude, and immediately north of the 52nd parallel of latitude. Counting rocks which rise little above high-water mark, they number 109 islands, but six only are worthy of the name, the rest being devoid of vegetation, with one or two exceptions. The six largest islands are:—

	Acreage.	Highest point in feet.	Population.
Great Blasket, - - -	1020	961	130
Innishtooskert, - - -	186	573	Uninhabited.
Innishvicillane, - - -	171	453	One family.
Innishnabro, - - -	102	583	Uninhabited.
Tearaght, - - - -	47	602	The light-house keepers.
Beginish, - - - -	32	57	Uninhabited.

A circle having a diameter of eight miles would include all the Blaskets, except a few rocks.

No botanist having ever examined this remote group with care, I made an effort to explore them in June, 1879. Having reached the town of Dingle, which is nine miles from the extreme west of the promontory, the police informed me that an unsuccessful attempt had recently been made to serve processes on the Blasket Islanders, and that they were hostile to strangers. This proved to be correct, and I found considerable difficulty in landing. At Dunquin, a small village on the mainland, opposite the Great Blasket, the boatmen declined to row me across. I heard subsequently they suspected I was a policeman in plain clothes. All sorts of excuses were made. Finally, after

four days' waiting, I procured a boat, the Rev. Father Egan, P.P., having spoken to the people on my behalf.

On approaching the Great Blasket, which is one mile distant from the nearest point of the mainland, the people were seen to run from the houses, and congregate on the edge of the cliff over the landing-place, shouting and gesticulating at the same time. Heaps of stones were piled, and the natives began to throw them at our boat.

Much loud conversation took place, which lasted a considerable time. In the end I was permitted to land, provided I kept at a distance from the houses. Seeing no harm was intended, the inhabitants became friendly, and many of them accompanied me during a walk of three hours, which I then took over the island. Unfavourable weather and want of time did not permit a longer visit in 1879, but I saw sufficient to make me anxious to examine the flora of the islands carefully, which could not be done without a stay of some days on the Great Blasket.

The Royal Irish Academy having given me a grant to explore the group, I again went to Dingle in July, 1880. No difficulty was now experienced in procuring boats. On the contrary, the people received me with many expressions of welcome, as I had interested myself on their behalf during the severe distress in the spring.

I landed on July 16. The mud cabins are of the poorest description. I slung my hammock from the rafters of a vacant one, called the schoolhouse. The curiosity of the natives was intense, and I suffered much from intruders when examining specimens, and placing them between the blotting sheets.

The houses on the Great Blasket are all built together on the end facing the mainland. Here the people have several patches of potatoes and oats, the only crops noticed. The rest of the island is pasture, and is grazed by cattle, sheep, and goats. There are no lakes, or even pools, on any of the Blaskets. The Great Blasket is three and a-half miles long by half a mile broad. Its longest axis extends in a south-westerly direction. In shape it resembles a ridge, for the most part 700 feet high, and for a mile its height exceeds 900 feet. Towards the south the ridge slopes much more gradually than on the northern face, which is almost perpendicular in many places.

The Great Blasket and Innishnabro consist of the Dingle beds, which are placed by Mr. Jukes between the Upper Silurian and Old Red Sandstone. Generally the Blasket group is Silurian, but trap rocks appear on Beginish and Innishvicillane. Near Dunquin the Dingle beds consist of green and purple grits and slates without fossils, and pass up into coarse Sandstones. Old Red Sandstone appears on the extreme north point of Innishtooskert. The conical Tearaght is composed of grits and conglomerates.

The cliffs and precipices are very grand, notably the north-western face of the Great Blasket and the north-eastern portion of Innishnabro, which latter resembles, when viewed from the sea, a cathedral 500 feet high, the towers, spires, and even doors and

windows, being represented.[1] Innishtooskert, has an isolated pinnacle of rock, with a great chasm in the cliff near it, scarcely less striking. The Tearaght is like a black tooth projecting from the ocean, its sides being rocky, desolate, and very barren. The landing is here effected with difficulty, even in calm weather. Myriads of sea-fowl, especially Puffins, swarm on the ledges of this distant island, which is nine miles from the mainland.

I observed that the cliffs on the northern face of all the islands were rather more productive in species than those on the south side. This is especially the case with the Great Blasket, and may in part be attributed to the greater frequency and violence of south and south-westerly winds, which in exposed situations would, doubtless, have an injurious influence on the growth of plants.

On the northern cliffs of the Great Blasket I noticed *Luzula sylvatica* plentiful, *Scilla nutans* and *Hymenophyllum unilaterale*: these are not found on any other island on the west coast of Ireland that I am aware of. *Primula vulgaris*, *Valeriana officinalis*, *Lychnis flos-cuculi*, *Viola sylvatica*, *Cardamine pratensis*, and other plants may be gathered here also, giving the vegetation an inland appearance. It is not usual to find such species associated on the face of a marine precipice exposed to the storms of the Atlantic.

Next to the Great Blasket, Innishvicillane is certainly the most fertile in species. Some cultivation exists here, and one family resides. Innishtooskert, though the largest of the group, except the Great Blasket, is the most barren island, for its size, I have visited on the west coast. It is uninhabited, and closely cropped by sheep. On the uninhabited island of Innishnabro I gathered *Lavatera arborea*, one or two conspicuous specimens growing on the cliff near the landing place. On the Tearaght Lavatera also grows. I noticed several plants growing on various parts of the rock. The fact of the lighthouse being on the Tearaght leaves room to question the nativity of Lavatera here. It may have been introduced by the keepers at one time. The occurrence of this species in suspicious localities along our coasts induces me to prefix a mark of doubt. If, however, Lavatera is anywhere indigenous in Ireland, it is probably on the Blaskets.

The late Mr. W. Andrews, in his numerous Papers in the Dublin Natural History Society's Proceedings, which refer principally to zoology, here and there notices some plants which occur on the Blasket Islands, viz., "a very fine species" of *Saxifraga geum*, "remarkable in having a series of glands of a rich rose-colour surrounding the base of the ovary, which give a remarkable appearance to its inflorescence." This form, Mr. Andrews states, he found at the extreme western point of the Great Blasket.[2]

I did not meet with any form of *Saxifraga geum* on the Blaskets,

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[1] See illustration in Mr. Andrews' "On the Sea Fisheries of Ireland."

[2] *Proceedings, Dub. Nat. Hist. Soc.*, vol. vi., part i., p. 85.

but I gathered strong and luxuriant specimens of *Sax. umbrosa* on the northern cliffs of the large island. At the entrance to Dingle Harbour Mr. A. G. More informs me he has gathered large and strong forms of *Sax. geum*. *Saxifraga umbrosa* was not observed on the southern side of either Innishvicillane, Innishtooskert, or the Great Blasket—the three islands on which it was noticed.

Hymenophyllum unilaterale (*Wilsoni*) Mr. Andrews met with on the Great Blasket "in rich abundance."[3] It can scarcely be called abundant, seeing that I only gathered it in one spot on the northern cliffs of the island.

Roccella fuciformis, a very rare and local lichen, is recorded by Mr. Andrews from the Tearaght Rock.[4] The late Dr. David Moore always considered that a large form of *Ramalina scopulorum* had been mistaken for it.[5] It is much to be wished that some competent cryptogamic botanist should visit the Tearaght, and set the matter at rest.

Cerastium arvense, var. *Andrewsii* (Syme), was also gathered by Mr. Andrews on the Blaskets. This variety I noticed in tolerable plenty on Innishvicillane, Innishnabro, and the Great Blasket, and it is the only form which occurs.

The occurrence of Lavatera has been already referred to. It appears to have escaped Mr. Andrews' attention.

Suaeda maritima, a species classed by Mr. Watson, in his Cybele Britannica, under the littoral zone, grow on the Tearaght between 400 and 500 feet above the sea-level. It occurs on the rocky face of the cliffs, and I did not gather it on any of the other islands. The waves around the Tearaght rise so high, that no plants can grow much below 150 to 200 feet.

Euphrasia officinalis does not assume that stunted form, with thick fleshy bracts and leaves packed close together, which I have noticed on the Islands Achill, Boffin, and Tory, in Ireland, and Staffa, in Scotland. The Blasket specimens are small, but the leaves and bracts are not broader than is usual in the inland form, and they are not succulent.

While examining the flora of the Blaskets, I took the opportunity of visiting the Skellig Rocks, twenty miles to the south, the only Irish breeding-place of the Gannet, and gathered twenty-three species on the Great Skellig. Here I observed a luxuriant form of *Cochlearia officinalis*, with large and strongly-reticulated pods. On the other hand, a variety of the same species, approaching var. *alpina* (Bab.), was gathered on the Great Blasket.

Landing on the Blaskets on Friday, July 16th, I left on the following Tuesday afternoon, having visited all the islands, except Beginish, which is flat and small in area, and of little interest. Alto-

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[3] *Proceedings, Dub. Nat. Hist. Soc.*, vol. ii. p. 173.
[4] *Proceedings, Dub. Nat. Hist. Soc.*, vol. i. p. 82.
[5] *Fide* Mr. A. G. More, who discovered *Roccella tinctoria* in the Isle of Wight.

gether 174 species, according to the London Catalogue of British Plants, 7th edition, were gathered, and specimens of most of them dried for examination. This includes *Spergularia rupestris*, a very common coast species, which I gathered only on the Skelligs, and which was probably overlooked on the Blaskets. Of the 174 species, 162 were noticed on the Great Blasket. The other islands were examined only with a view to detect species not noticed on the largest island, and the list of species for each is incomplete. Innishtooskert is so barren that it is seldom referred to in my list, and I have not indicated it by a separate letter, as in the case of the other islands.

Five distinct groups of islands have now been examined on the west coast of Ireland. Professor E. P. Wright, in 1866, and Mr. H. C. Hart in 1869,[6] visited the Arran Islands, in Galway Bay.[7] Mr. A. G. More, in 1875, visited with me Bofin Island, county Mayo.[8] Tory Island, county Donegal, was visited in 1877 by myself;[9] and Mr. H. C. Hart, in 1879, visited Aran Island, county Donegal.[10]

We may now add the Blasket Islands to the number; and as these local lists are valuable, not only for the sake of comparison with the portions of the mainland respectively opposite each island, but also with each other, I have thought it desirable now that we have five groups to compare for the first time, to draw out in a tabular form a list of species which shows at a glance all the plants which have been recorded from the five groups, as well as the islands on which they occur, and from which they are absent.

The areas of the five groups, with the number of species recorded from (and compared with each other) peculiar species, are:—

	Acres.	Total species.	Peculiar species.
Arran Islands, Galway . .	10781	372	130
Aran Island, Donegal, . .	4355	232	23
Innishbofin, ...	2312	303	36
The Blasket Islands, . .	1560	174	8
Tory Island, ...	785	145	1

[6] "Notes on the Flora of the Islands of Arran," *Proceedings, Dub. Nat. Hist. Soc.*, vol. v. p. 96.

[7] *A List of Plants found on the Islands of Arran, Galway Bay.* Hodges, Foster, & Co. Dublin. 1875. And *Journal of Botany*, 1875, p. 111.

[8] *Proceedings, Royal Irish Academy*, 2nd series, vol. ii. (Science) p. 553; and *Journal of Botany*, 1876, p. 373.

[9] *Journal of Botany*, vol. viii. (new series) p. 263, September, 1879.

[10] *Journal of Botany*, vol. x. (new series) p. 19, January, 1881.

The eight species peculiar to the Blaskets, and which have not been observed on any of the other islands, are—

Cardamine sylvatica.	Luzula sylvatica.
Lychnis githago.	Carex disticha.
Stellaria graminea.	,, pilulifera.
Scilla nutans.	Hymenophyllum unilaterale.

The occurrence of *Luzula sylvatica* in abundance, and *Scilla nutans* in tolerable plenty on a marine cliff on the west coast, is certainly unusual. *Carex disticha* grows on the summit of the Great Blasket (Croaghmore), 961 feet.

That there should be 130 species on the Arran Islands, in Galway Bay, not recorded from any of the other groups, is due to its much larger and more diversified surface as well as its limestone formation.

There are only seventy-two species which occur on all the islands.

The following plants, observed on the Blaskets, belong to Mr. H. C. Watson's "Atlantic Type":—

Lavatera arborea.	Crithmum maritimum.
Sedum anglicum.	Scirpus Savii.
Cotyledon umbilicus.	Hymenophyllum unilaterale.
Saxifraga umbrosa.	Nephrodium æmulum.

One species, *Koeleria cristata*, is new to district No. 1 of the Cybele Hibernica.

Plants which elsewhere are certainly native appear to be introduced on the Blaskets, as they are confined to the cultivated ground or its neighbourhood.

Though scanty, the flora of the Blaskets is not without interest. The extreme westerly position of these islands and their situation off the coast of Kerry, with their genial climate and characteristic vegetation, make a list of their species useful, as affording materials for a comparison with the other island floras, which the tabular catalogue will, I trust, prove useful in facilitating.

LIST OF THE PLANTS FOUND ON THE BLASKET ISLANDS.

B after a species signifies Great Blasket; V, Innishvicillane; N, Innishnabro; T, Tearaght; S, Skelligs.

Those certainly introduced are marked *, those possibly introduced †, those probably ‡.

RANUNCULACEAE.

Ranunculus flammula (Linn.) B.
Ranunculus repens (Linn.) Not common. B. V.

Fumariaceae.

‡*Fumaria confusa* (Linn.) A colonist among crops. B.

Cruciferae.

Cakile maritima (Scop.) On the small strand. B.
‡*Sinapis arvensis* (Linn.) B. } Colonists in cultivated land.
‡*Brassica napus* (Linn.) B. }
Cardamine pratensis (Linn.) In one or two places on the north side. B.
Cardamine sylvatica (Link.) North side. B.
Cochlearia officinalis (Linn.) Very fine on the Great Skellig, the pods being large and much reticulated; on the other hand, a small form found on the Great Blasket approaches var. *alpina* (Bab.) B. S.
†*Capsella Bursa-pastoris* (Moench.) I believe introduced. B. V.

Violaceae.

Viola palustris (Linn). Common. B. V.
Viola sylvatica (Fries.) Great Blasket, north side. B. N.

Polygalaceae.

Polygala vulgaris (Linn.) Common. B. V.
[*Polygala depressa* (Wender). I believed to have been gathered also, but no specimen was preserved].

Caryophyllaceae.

Silene maritima (With.) Common. B. S. V.
Lychnis Flos-cuculi (Linn.) Only seen on the north side on the Great Blasket. B. N.
**Lychnis Githago* (Lam.) Among corn; a colonist. B.
Cerastium tetrandrum (Curt.) Common. B. S. N. T.
Cerastium triviale (Link.) Common. B.
Cerastium arvense (Linn.) Var. *Andrewsii* (Syme). Common on the three islands, and the only form observed. B. V. N.
Stellaria media (With.) B. V.
Stellaria graminea (Linn.) Rare; only in one spot. B.
Honkeneja peploides (Ehrh.) Only on the strand. B.
Sagina maritima (Don.) Frequent. B. S.
Sagina procumbens (Linn). Common. B. V.
‡*Spergula arvensis* (Linn.) Among corn; the form without papillae on the seeds. B.

Spergularia neglecta (Kindb.) Rare. V.
Spergularia rupestris (Lebel.) I have no specimen from the Blaskets, but it may have been overlooked. S.

PORTULACACEAE.

Montia fontana (Linn.) Rare. B.

HYPERICACEAE.

Hypericum pulchrum (Linn.) North side. B.

MALVACEAE.

†*Lavatera arborea* (Linn.) This plant occurs only on Innishnabro and the Tearaght. The former island is uninhabited. Only one or two specimens were observed on Innishnabro; on the Tearaght several. It is such a doubtful native on our coasts that I have hesitated to admit it as indigenous even on these wild islands; but it may be so. N. T.

LINACEAE.

Radiola millegrana (Sm.) Very diminutive and difficult to find. I observed it only on the south side in one or two spots. B.

LEGUMINIFERAE.

Anthyllis vulneraria (Linn.) Not common. B. V.
‡*Trifolium pratense* (Linn). Probably introduced by cultivation. B.
Trifolium repens (Linn.) Common. B. S. N.
Lotus corniculatus (Linn.) Common. B. V.
Vicia Cracca (Linn.) Scarce. B.
Vicia sepium (Linn.) Not noticed on Great Blasket. V.
Lathyrus pratensis (Linn.) Uncommon. B.

ROSACEAE.

†*Alchemilla arvensis* (Scop.) Rare, and a doubtful native.
Potentilla Tormentilla (Schenk.) Plentiful. B. N.
Potentilla anserina (Linn.) Common. B. V.
Rubus discolor (W. & N.) There is but one diminutive bramble on the Great Skellig growing out of a crevice in the rock near the summit, 714 feet. It is well known to the light-keepers as the "only Blackberry on the Skelligs." There are two or three bushes on the Great Blasket and on Innishvicillane. Species supposed to be *R. discolor*, but not determined satisfactorily. B. V. S.

LYTHRACEAE.

Lythrum Salicaria (Linn.) Scarce. B.
Peplis Portula (Linn.) In one spot. V.

ONAGRACEAE.

[illegible] *obscurum* (Schreb.) Near the village. B.

H[illegible]IACEAE.

Callitriche pl[illegible]mmon. B. V.

[illegible]ACEAE.

Sedum anglicum [illegible] Great Skellig this species is very abundant. [illegible] face it forms dense mats several yards across, to [illegible]n of every other plant, and when in full bloom th[illegible]e flowers is perceptible at a considerable distan[illegible]tion of the wind. B. S. N.
Cotyledon Umbilicus [illegible]ndant. I did not see *Sedum Rhodiola*, which m[illegible]a expected. B. S. N.

SAXIFRAGACEAE.

Saxifraga umbrosa (Linn.) Common on the north cliffs of the Great Blasket. Sparingly on Innishvicillane cliffs, facing the Great Blasket. I did not meet with any form of *Saxifraga Geum*. (*See* observations, page 370.) B. V.

UMBELLIFERAE.

Hydrocotyle vulgaris (Linn.) Common. B. V.
Crithmum maritimum (Linn.) Scarce. B. V.
Angelica sylvestris (Linn.) As elsewhere on the west coast of Ireland and Scotland a characteristic plant of the cliffs, but not as plentiful as I have noticed it further north. B. V.
**Heracleum sphondylium* (Linn.) Only near houses. B.
Daucus Carota (Linn.) B.

ARALIACEAE.

Hedera Helix (Linn.) Only near the strand. No form approaching the Irish Ivy. B.

RUBIACEAE.

Galium verum (Linn.) Banks near the strand. B.
Galium saxatile (Linn.) Common. B.
‡*Galium Aparine* (Linn.) A colonist. B. V.

VALERIANACEAE.

Valeriana officinalis (Linn.) Only on the northern face in one spot with *Scilla nutans*. B.

COMPOSITAE.

Carduus lanceolatus (Linn.) Native, I believe. B. V.
† *Carduus arvensis* (Curt.) Possibly introduced. B.
Arctium intermedium (Lange.) B. V.
Centaurea nigra (Linn.) Probably not native on the Skelligs. B. S. V.
Matricaria inodora (Linn.) Var *maritima* (Bab.) B. S.
Achillea Millefolium (Linn.) Not common. B. V.
‡*Artemesia vulgaris* (Linn.) A colonist; near the houses. B.
Gnaphalium uliginosum (Linn.) B.
‡*Senecio vulgaris* (Linn.) Near a garden. V.
Senecio Jacobæa (Linn.) Plentiful on Innishnabro, forming yellow patches; growth stunted. B. N.
Bellis perennis (Linn.) B.
Solidago Virga-aurea (Linn.) B.
Tussilago Farfara (Linn.) B.
‡*Lapsana communis* (Linn.) Only near houses. B.
Hypochæris radicata (Linn.) Near the village. B.
Leontodon autumnalis (Linn.)
Leontodon autumnalis, var. *pratensis* (Syme.) } Both observed. B. V.
‡*Taraxacum officinale* (Wigg.) Near the cottage; not noticed on Great Blasket. V.
†*Sonchus oleraceus* (Linn.) B.
†*Sonchus asper* (Hoffm.) S. V.
‡*Sonchus arvensis* (Linn.) B.
} All three perhaps introduced—the last a colonist among corn and potatoes.

CAMPANULACEAE.

Jasione montana (Linn.) Plentiful. B. S. V.

ERICACEAE.

Vaccinum Myrtillus (Linn.) Common on the northern face. B.
Erica Tetralix (Linn.) Not uncommon. B. V.
Erica cinerea (Linn.) Plentiful. B. N.
Calluna vulgaris (Salisb.) B. N.

GENTIANACEAE.

Erythræa Centaurium (Pers.) Pasture near the village. B.

SCROPHULARACEAE.

‡*Veronica polita* (Fries.) B. } Colonists, near houses and p
†*Veronica arvensis* (Linn.) B. } gardens.
Veronica serpyllifolia (Linn.) Looks native. B.
Euphrasia officinalis (Linn.) Not the fleshy and compact f have noticed on nd, Mayo; and also on the Isl Staffa, Scotl imens were, however, small.
†*Bartsia Odontites*
Pedicularis sylvatica equent. B.

IATAE.

Thymus Serpyllum (l quent. B. V.
Prunella vulgaris (Lin ion. B. V.
Stachys palustris
Galeopsis Tetrah 's of thatched houses, &c. B.
‡*Lamium amplexicaule* (Linn.) } All colonists in potato g
‡*Lamium incisum* (Willd.) B. } and among corn; *L. a*
‡*Lamium purpureum* (Linn.) B. V. } *caule* rare.
Teucrium Scorodonia (Linn.) Thoroughly exposed on the sl the Great Blasket and Innishnabro to Atlantic storms.

BORAGINACEAE.

†*Myosotis arvensis* (Hoffm.) Near cultivation. B. V.

PRIMULACEAE.

Primula vulgaris (Huds.) On the cliffs of the Great Blaske growing in exposed situations. B.
Anagallis arvensis (Linn). Far from cultivation on the uninl island of Innishnabro. B. N.
Anagallis tenella (Linn.) Common. B. V.

PLUMBAGINACEAE.

Armeria maritima (Willd.) Common. B. S.

PLANTAGINACEAE.

‡ *Plantago major* (Linn.) With *Trifolium pratense* in pastures; a doubtful native. B.
† *Plantago lanceolata* (Linn.) B. S. N.
Plantago maritima (Linn.) Strange to say this very common species is not marked off in my list as occurring on the Blaskets. It must be abundant, and I have therefore inserted it. B. S.
Plantago coronopus (Linn.) B. S.

CHENOPODIACEAE.

Suaeda maritima (Dum.) Only noticed on the Tearaght Rock, and at a considerable elevation, probably 400 feet above the sea, on the rocky face of the cliff. T.
Beta maritima (Linn.) Not seen on the Great Blasket; abundant on the Skelligs. S. N.
‡ *Chenopodium album* (Linn.) Among crops. B.
‡ *Atriplex angustifolia* (Sm.) As in Boffin, I did not meet with *A. hastata* (Linn.) B.
Atriplex Babingtonii (Woods.) On the high margins of the cliffs up to 400 feet above the sea. B. S. V.

POLYGONACEAE.

† *Rumex obtusifolius* (Auct.) B. V.
† *Rumex crispus* (Linn.) B.
Rumex Acetosa (Linn.) B. S. V. N.
Rumex Acetosella (Linn.) Very luxuriant on the northern face of the Great Blasket among sheltered rocks. B.
Polygonum aviculare (Linn.) B.
Polygonum Persicaria (Linn.) B. V.

EMPETRACEAE.

Empetrum nigrum (Linn.) In one place, about 700 feet above the sea on the northern cliffs. Procured only by dislodging the specimen with stones. B.

EUPHORBIACEAE.

‡ *Euphorbia Helioscopia* (Linn.) Sparingly among crops. B.

URTICACEAE.

...ca (Linn.) Only near houses, and on the borders of cu... vated ground. B.

ORCHIDACEAE.

Orchis maculata (Linn.) Rare—in one spot only on the south slope. B.

LILIACEAE.

Scilla nutans (Sm.) Only on the north side, growing among ro... on the cliffs, with *Prim... la vulgaris, Valeriana officina...* &c. B.

JUNCACEAE.

Luzula sylvatica (Beck.) Plentiful on the northern cliffs. B.
Luzula multiflora (Koch.) Common. B. N.
Juncus conglomeratus (Linn.) B. V.
Juncus lamprocarpus (Ehrh.) B.
Juncus supinus (Moench.) Common. B. V.
Juncus bufonius (Linn.) V.
Juncus squarrosus (Linn.) Hilly pastures. B.

CYPERACEAE.

Scirpus setaceus (Linn.) Frequent. B.
Scirpus Savii (S. & M.) Less common. B.
Eriophorum angustifolium (Roth.) Frequent. B. V.
Carex disticha (Huds.) Only on the highest portion of the G... Blasket. B.
Carex stellulata (Good.) Common. B. V. N.
Carex vulgaris (Fries.) Common. B.
Carex glauca (Scop.) North of the village. B.
Carex pilulifera (Linn.) Frequent. B.
Carex panicea (Linn.) Common. B. V.
Carex binervis (Sm.) Abundant. B.
Carex flava (Linn.) Var. *lepidocarpa* (Tausch.) Sparingly. B.

GRAMINEAE.

Anthoxanthum odoratum (Linn.) Frequent. B. N.
Agrostis canina (Linn.) Rare. B.
Agrostis alba (Linn.) Plentiful. B. S. V.
Agrostis vulgaris (With.) Common. B.
Aira caryophyllea (Linn.) B.
Aira praecox (Linn.) B.
Avena elatior (Linn.) B. V.
Holcus lanatus (Linn.) On the Great Skellig and Tearaght this grass grows very luxuriant. B. S. V.
Triodia decumbens (Beauv.) Common. B. V.
Koeleria cristata (Pers.) Shore near the village. B.
Sclerochloa loliacea (Woods.) Sandy strand near the village. B.
Poa annua (Linn.) B.
Poa pratensis (Linn.) B.
Poa trivialis (Linn.) B. V.
Dactylis glomerata (Linn.) B.
Festuca sciuroides (Roth.) B.
Festuca ovina (Linn.) B. V.
Festuca rubra (Linn.) B. V. T.
Bromus mollis (Linn.) Rare, and possibly introduced. B.
Triticum repens (Linn.) B.
Triticum junceum (Linn.) Near the strand. B.
Lolium perenne (Linn.) Relic of cultivation. B.
Nardus stricta (Linn.) Plentiful. B. V.

FILICES.

Hymenophyllum unilaterale (Willd.) On the northern cliffs among loose rocks. B.
Pteris aquilina (Linn.) Common. B. V.
Lomaria spicant (Desv.) B.
Asplenium marinum (Linn.) No specimens from the Blaskets, but I believe it was observed. S.
Asplenium Adiantum nigrum (Linn.) Frequent. B.
Athyrium Filix-foemina (Bernh.) Common. B. V.
Nephrodium dilatatum (Desv.) Frequent. B. N. V.
Nephrodium æmulum (Baker.) Not uncommon. B. N.
Polypodium vulgare (Linn.) Scarce. B. N.

LIST OF PLANTS FOUND ON THE FOLLOWING ISLANDS:—

nd, Co. Donegal.	Arran Islands, Galway Bay.
nd, Co. Donegal.	Blasket Islands, Co. Kerry.
n Island, Co. Mayo.	

(See page 372, foot-notes.)

LIST OF PLANTS.	Tory.	North Aran.	Bofin.	South Arran.	Blaskets.
Thalictrum minus,	—	—	—	4	—
Ranunculus trichophyllus,	—	—	3	4	—
,, Baudotti,	1	—	3	—	—
,, heterophyllus,	—	—	—	4	—
,, hederaceus,	1	2	3	4	—
,, flammula,	1	2	3	4	5
,, lingua,	—	—	—	4	—
,, acris,	—	2	3	4	—
,, repens,	1	2	3	4	5
,, bulbosus,	—	2	3	4	—
Caltha palustris,	—	2	—	—	—
Aquilegia vulgaris,	—	—	—	4	—
Nuphar lutea,	—	—	3	—	—
Papaver dubium,	—	—	—	4	—
Glaucium luteum,	—	—	—	4	—
Fumaria pallidiflora,	—	—	3	4	—
,, confusa,	—	—	3	—	5
,, officinalis,	—	—	—	4	—
Cakile maritima,	—	2	3	4	5
Crambe maritima,	—	—	—	4	—
Rhaphanus Raphanistrum,	—	—	3	4	—
,, maritimus,	—	—	3	4	—
Sinapis arvensis,	1	—	3	—	5
,, alba,	—	—	3	4	—
,, nigra,	—	—	3	4	—
Brassica Napus,	1	—	3	—	5
Sisymbrium officinale,	—	—	3	4	—
,, Alliaria,	—	—	—	4	—
Hesperis matronalis,	—	—	—	4	—
Matthiola sinuata,	—	—	—	4	—
Cardamine pratensis,	—	—	3	4	5
,, hirsuta,	—	2	—	4	—
,, sylvatica,	—	—	—	—	5
Arabis ciliata,	—	—	—	4	—
,, hirsuta,	—	—	—	4	—
Barbarea vulgaris,	—	—	—	4	—
Nasturtium officinale,	—	2	3	4	—
,, palustre,	—	—	—	4	—
Cochlearia officinalis,	1	—	—	4	5
,, danica,	—	—	3	4	—
Draba verna,	—	2	—	—	—
Thlaspi arvense,	—	—	—	4	—
Capsella bursa-pastoris,	1	—	3	4	5

List of Plants.	Tory.	North Aran.	Bofin.	South Arran.	Blaskets.
idyma,	—	—	3	—	—
Coronopus,	—	—	3	4	—
ea,	—	—	—	4	—
teola,	—	—	—	4	—
num guttatum,	—	—	3	—	—
canum,	—	—	—	4	—
stris,	—	2	3	4	5
,	—	—	—	4	—
itica,	1	—	3	4	5
ia,	—	—	3	—	—
lor,	—	2	—	4	—
sii,	—	—	—	4	—
undifolia.	—	2	3	—	—
ulgaris,	—	—	—	4	5
pressa,	1	2	3	—	5
ta,	—	—	—	4	—
itima,	1	2	3	4	5
Flos-cuculi,	—	—	3	—	5
githago,	—	—	—	—	5
tetrandrum,	1	2	3	—	5
glomeratum,	—	2	3	4	—
triviale,	1	2	3	4	5
arvense (Andrewsii),	—	—	—	4	5
edia,	1	2	3	4	5
uminea,	—	—	—	—	5
ginosa,	—	2	—	—	—
rpyllifolia,	—	—	3	4	—
peploides,	—	2	3	4	5
a,	—	—	—	4	—
itima,	1	—	—	4	5
ala,	—	2	—	4	—
umbens,	1	2	3	4	5
ulata,	—	—	3	4	—
sa,	—	—	3	4	—
vensis,	1	—	3	—	5
neglecta,	1	2	3	4	5
rupestris,	1	2	3	4	5
ana,	1	2	3	—	5
andra,	—	—	3	—	—
Androsæmum,	—	—	3	4	—
tetrapterum,	—	—	3	4	—
humifusum,	—	—	3	4	—
pulchrum,	—	2	3	4	5
elodes,	—	—	3	—	—
oorea,	—	—	—	4	5
stris,	—	—	3	4	—
egrana,	1	2	3	—	5
articum,	—	2	3	4	—
inguineum.	—	—	—	4	—
olle,	—	2	3	4	—
sectum,	—	—	3	4	—
cidum,	—	—	—	4	—
obertianum,	—	2	3	4	—

List of Plants.	Tory.	North Aran.	Bofin.	South Arran.
Erodium cicutarium,	—	2	3	4
,, moschatum,	—	—	—	4
Oxalis Acetosella,	—	2	3	—
Ilex Aquifolium,	—	—	—	4
Euonymus europæus,	—	—	—	4
Rhamnus catharticus,	—	—	—	4
Ulex europæus,	—	2	—	—
,, Gallii,	—	—	—	4
Anthyllis vulneraria,	—	2	3	4
Medicago lupulina,	—	—	—	4
Trifolium pratense,	1	2	3	4
,, medium,	—	2	—	—
,, arvense,	—	—	—	4
,, repens,	1	2	3	4
,, procumbens,	—	—	—	4
,, minus,	—	2	3	4
Lotus corniculatus,	1	2	3	4
,, major,	—	—	—	4
Astragalus hypoglottis,	—	—	—	4
Vicia Cracca,	1	2	3	4
,, sepium,	—	2	3	4
,, sativa,	—	—	3	—
,, angustifolia,	—	—	3	—
Lathyrus pratensis,	—	—	3	4
Prunus spinosa,	—	—	3	4
Spiræa Ulmaria,	—	2	3	4
Agrimonia Eupatoria,	—	—	3	4
Poterium Sanguisorba,	—	—	—	4
Alchemilla arvensis,	—	2	—	4
,, vulgaris,	—	—	—	4
Potentilla Tormentilla,	1	2	3	4
,, procumbens,	—	—	3	—
,, reptans,	—	2	3	4
,, anserina,	1	—	3	4
Comarum palustre,	—	—	3	—
Fragaria vesca,	—	—	—	4
Rubus discolor,	—	2	3	4
,, thyrsoideus,	—	—	3	—
,, carpinifolius,	—	—	3	—
,, villicaulis,	—	—	3	—
,, cæsius,	—	—	—	4
,, saxatilis,	—	—	—	4
Geum urbanum,	—	—	—	4
Rosa canina,	—	—	3	4
,, spinosissma,	1	2	3	4
Cratægus Oxyacantha,	—	—	—	4
Lythrum Salicaria,	1	2	3	4
Peplis Portula,	1	2	3	—
Epilobium hirsutum,	—	—	—	4
,, parviflorum,	—	—	3	4
,, montanum,	—	2	3	4
,, obscurum,	—	—	3	4
,, palustre,	—	2	3	—

List of Plants.	Tory.	North Aran.	Bofin.	South Arran.	Blaskets.
utetiana,	—	—	—	4	—
yllum alterniflorum,	1	2	3	4	—
s vulgaris,	—	—	—	4	—
he verna,	1	2	3	4	—
platycarpa,	1	2	3	—	5
hamulata,	—	—	3	—	—
Rhodiola,	—	2	—	4	—
anglicum,	1	2	3	4	5
acre,	—	2	3	4	—
on Umbilicus,	—	—	—	4	5
a umbrosa,	—	—	3	—	5
tridactylites,	—	—	—	4	—
hirta,	—	2	—	—	—
hypnoides,	—	—	—	4	—
tyle vulgaris,	1	2	3	4	5
europæa,	—	—	—	4	—
m maritimum,	—	—	—	4	—
graveolens,	—	—	—	4	—
dium nodiflorum,	1	2	—	4	—
inundatum,	—	—	3	4	—
lla magna,	—	—	—	4	—
lium Podagraria,	—	2	—	—	—
Cynapium,	—	—	—	4	—
um scoticum,	1	—	—	4	—
m maritimum,	1	—	3	4	5
a sylvestris,	1	2	3	4	5
a sativa,	—	—	—	4	—
um Sphondylium,	1	2	3	4	5
Carota,	1	2	3	4	5
Anthriscus,	—	—	—	4	—
odosa,	—	—	—	4	—
yllum Anthriscus,	—	—	—	4	—
sylvestre,	—	—	—	4	—
maculatum,	—	—	3	4	—
m olusatrum,	—	—	—	4	—
Helix,	1	2	3	4	5
sanguinea,	—	—	—	4	—
us nigra,	—	—	3	4	—
Ebulus,	—	—	—	4	—
m Opulus,	—	—	—	4	—
Periclymenum,	1	2	3	4	—
eregrina,	—	—	—	4	—
boreale,	—	—	—	4	—
verum,	—	2	3	4	5
saxatile,	—	2	3	—	5
sylvestre,	—	—	—	4	—
palustre,	—	—	3	4	
Witheringii,	1	—	3	—	
Aparine,	—	—	3	4	5
a cynanchica,	—	—	—	4	—
ia arvensis,	—	—	—	4	—
a officinalis,	—	—	—	4	5
ella olitoria,	—	—	—	4	—

List of Plants.	Tory.	North Aran.	Bofin.	South Arran.
ı succisa, ...	1	2	3	4
ı Marianum, ...	—	—	—	4
ı tenuiflorus, ...	—	—	—	4
„ nutans, ...	—	—	—	4
„ lanceolatus, ...	1	2	3	4
„ palustris, ...	—	2	3	—
„ pratensis, ...	1	2	—	—
„ arvensis, ...	1	2	3	4
Carlina vulgaris, ...	—	—	—	4
Arctium minus, ...	—	2	—	—
„ intermedium, ...	1	—	3	4
Centaurea nigra, ...	1	2	3	4
„ Scabiosa, ...	—	—	3	4
Chrysanthemum segetum, ...	1	2	3	4
„ Leucanthemum, . . .	—	2	3	4
Matricaria inodora, ...	1	2	3	4
Tanacetum vulgare, ...	—	—	—	4
Achillea Millefolium, ...	—	2	3	4
„ Ptarmica, ...	—	2	3	4
Artemisia Absinthium, ...	—	—	—	4
„ vulgaris, ...	1	2	3	4
Filago germanica, ...	—	—	—	4
Gnaphalium uliginosum, ...	1	2	3	4
„ dioicum, ...	—	2	—	4
Senecio vulgaris, ...	1	2	3	4
„ sylvaticus, ...	1	2	3	—
„ Jacobæa, ...	1	2	3	4
„ aquaticus, ...	1	2	3	4
Inula dysenterica, ...	—	—	3	4
Bellis perennis, ...	1	2	3	4
Aster Tripolium, ...	—	—	3	4
Solidago Virga-aurea, ...	1	2	3	4
Tussilago Farfara, ...	—	2	3	4
Eupatorium cannabinum, ...	—	—	—	4
Lapsana communis, ...	—	2	3	4
Hypochæris radicata, ...	1	2	3	4
Leontodon hirtus, ...	—	—	3	—
„ autumnalis, ...	1	2	3	4
Taraxacum officinale, ...	1	2	3	4
Sonchus oleraceus, ...	1	2	3	4
„ asper, ...	1	2	3	4
„ arvensis, ...	—	2	3	3
Crepis virens, ...	—	2	—	4
Hieracium Pilosella, ...	—	2	3	4
„ anglicum, ...	—	—	—	4
Lobelia Dortmanna, ...	—	2	3	—
Jasione montana, ...	1	2	3	—
Campanula rotundifolia, ...	—	2	3	4
Vaccinium Myrtillus, ...	—	2	—	—
Arctostaphylos Uva-ursi, ...	—	2	—	—
Erica Tetralix, ...	—	2	3	—
„ cinerea, ...	1	2	3	4
Calluna vulgaris, ...	1	2	3	4

LIST OF PLANTS.	Tory.	North Aran.	Bofin.	South Arran.	Blaskets.
Fraxinus excelsior,	—	—	—	4	—
Erythræa Centaurium,	1	2	3	4	5
Chlora perfoliata,	—	—	—	4	—
Gentiana verna,	—	—	—	4	—
,, campestris,	—	2	3	4	—
Menyanthes trifoliata,	—	2	3	4	—
Convolvulus arvensis,	—	—	—	4	—
,, sepium,	—	2	3	4	—
,, Soldanella,	—	—	—	4	—
Solanum dulcamara,	—	—	—	4	—
Verbascum thapsus,	—	—	—	4	—
Scrophularia aquatica,	—	—	3	—	—
,, nodosa,	—	—	—	4	—
Digitalis purpurea,	—	2	—	—	—
Linaria vulgaris,	1	—	—	—	—
Veronica hederifolia,	—	2	—	4	—
,, polita,	—	—	3	—	5
,, agrestis,	—	—	3	4	—
,, arvensis,	—	—	3	4	5
,, serpyllifolia,	—	2	—	4	5
,, officinalis,	—	2	—	4	—
,, Chamædrys,	—	2	3	4	—
,, Anagallis,	—	—	3	4	—
,, Beccabunga,	—	—	3	4	—
Euphrasia officinalis,	1	2	3	4	5
Bartsia odontites,	1	2	3	4	5
Pedicularis palustris,	—	—	3	4	—
,, sylvatica,	—	2	3	4	5
Rhinanthus Crista-galli,	1	2	3	4	—
Orobanche Hederæ,	—	—	—	4	—
Lycopus europæus,	—	—	—	4	—
Mentha aquatica,	—	—	3	4	—
,, arvensis,	—	—	—	4	—
Thymus serpyllum,	1	2	3	4	5
Calamintha officinalis,	—	—	—	4	—
Nepeta Glechoma,	—	—	—	4	—
Prunella vulgaris,	1	2	3	4	5
Scutellaria minor,	—	—	3	—	—
Marrubium vulgare,	—	—	—	4	—
Stachys palustris,	1	2	3	4	5
,, sylvatica,	—	—	—	4	—
,, arvensis,	1	—	3	4	—
Galeopsis Tetrahit,	—	2	3	4	5
Lamium amplexicaule,	1	—	—	—	5
,, intermedium,	1	2	—	—	—
,, incisum,	1	2	—	—	5
,, purpureum,	1	2	3	4	5
Ajuga reptans,	—	—	—	4	—
,, pyramidalis,	—	—	—	4	—
Teucrium Scorodonia,	—	—	3	4	5
Lithospermum officinale,	—	—	—	4	—
Myosotis cæspitosa,	1	2	3	—	—
,, palustris,	—	—	—	4	—

List of Plants.	Tory.	North Aran.	Bofin.	South Arran.	[illegible]
Myosotis repens,	—	2	—	—	—
,, arvensis,	1	2	3	4	5
,, versicolor,	—	—	—	4	—
Symphytum officinale,	—	—	—	4	—
Pinguicula vulgaris,	—	—	3	—	—
,, lusitanica,	—	—	3	—	—
Utricularia minor,	—	—	3	—	—
Primula vulgaris,	—	2	3	4	5
Lysimachia nemorum,	—	—	—	4	—
Anagallis arvensis,	—	2	3	4	5
,, tenella,	1	2	3	4	5
Centunculus minimus,	—	—	3	—	—
Glaux maritima,	1	2	3	4	—
Samolus valerandi,	—	—	3	4	—
Armeria maritima,	1	2	3	4	5
Statice occidentalis,	—	—	—	4	—
Plantago major,	1	2	3	4	5
,, lanceolata,	1	2	3	4	5
,, maritima,	1	2	3	4	5
,, coronopus,	1	2	3	4	5
Littorella lacustris,	1	2	3	4	—
Suæda maritima,	—	—	—	4	5
Salsola Kali,	—	2	3	4	—
Salicornia herbacea,	—	—	—	4	—
Beta maritima,	1	2	—	4	5
Chenopodium album,	1	2	3	4	5
Atriplex littoralis,	—	—	—	4	—
,, angustifolia,	1	2	3	4	5
,, erecta,	—	2	3	—	—
,, deltoidea,	—	2	—	—	—
,, Babingtonii,	1	2	3	—	5
Rumex conglomeratus,	—	—	—	4	—
,, obtusifolius,	1	2	3	4	5
,, crispus,	1	—	3	—	5
,, Acetosa,	1	2	3	4	5
,, Acetosella,	1	2	3	4	5
Polygonum convolvulus,	—	—	3	4	—
,, aviculare,	1	2	3	4	5
,, Raii,	—	—	—	4	—
,, Hydropiper,	—	2	3	4	—
,, Persicaria,	—	2	3	4	5
,, amphibium,	1	—	3	4	—
Empetrum nigrum,	1	2	3	—	5
Euphorbia Helioscopia,	—	2	3	4	5
,, Paralias,	—	—	—	4	—
,, portlandica,	—	—	—	4	—
,, Peplus,	—	—	—	4	—
Parietaria officinalis,	—	—	—	4	—
Urtica dioica,	1	2	3	4	5
,, urens,	1	2	3	4	—
Humulus Lupulus,	—	—	—	4	—
Quercus robur,	—	2	—	4	—
Corylus avellana,	—	2	—	4	—

List of Plants.	Tory.	North Aran.	Befin.	South Arran.	Blaskets.
Alnus glutinosa,	—	2	—	—	—
Betula alba,	—	2	—	—	—
Myrica Gale,	—	2	3	—	—
Populus alba,	—	—	—	4	—
,, tremula,	—	2	3	—	—
Salix viminalis,	—	—	3	4	—
,, Smithiana,	—	—	3	—	—
,, cinerea,	—	2	—	—	—
,, aurita,	—	—	3	—	—
,, caprea,	—	—	—	4	—
,, repens,	1	2	3	4	—
Juniperus communis,	—	—	—	4	—
,, nana,	—	2	3	—	—
Sparganium affine,	1	—	3	—	—
,, minimum,	—	2	—	—	—
Arum maculatum,	—	—	—	4	—
Lemna minor,	—	2	3	4	—
Potamogeton natans,	—	—	3	4	—
,, polygonifolius,	1	2	3	—	—
,, pusillus,	—	—	3	—	—
,, pectinatus,	—	—	3	4	—
Zostera marina,	—	2	3	4	—
Triglochin palustre,	1	—	3	4	—
,, maritimum,	—	—	—	4	—
Alisma ranunculoides,	—	—	—	4	—
Orchis pyramidalis,	—	—	—	4	—
,, mascula,	—	—	—	4	—
,, maculata,	1	2	3	—	5
Gymnadenia conopsea,	—	—	—	4	—
Habenaria viridis,	—	—	—	4	—
Spiranthes autumnalis,	—	—	—	4	—
Iris Pseud-acorus,	1	2	3	4	—
Narcissus biflorus,	—	—	—	4	—
Allium Babingtonii,	—	—	3	4	—
Scilla nutans,	—	—	—	—	5
Narthecium ossifragum,	—	2	3	—	—
Eriocaulon septangulare,	—	—	3	—	—
Luzula sylvatica,	—	—	—	—	5
,, campestris,	—	—	—	4	—
,, multiflora,	1	2	3	—	5
Juncus maritimus,	—	2	—	—	—
,, conglomeratus,	1	—	3	—	5
,, effusus,	—	2	3	4	—
,, acutiflorus,	1	—	3	4	—
,, lamprocarpus,	—	—	3	—	5
,, supinus,	1	—	3	—	5
,, bufonius,	1	2	3	4	5
,, Gerardi,	1	—	3	—	—
,, compressus,	—	2	—	—	—
,, squarrosus,	—	2	3	—	5
Schœnus nigricans,	1	—	3	4	—
Rhynchospora alba,	—	—	3	—	—
Scirpus palustris,	1	2	3	—	—

List of Plants.	Tory.	North Aran.	Bofin.	South Arran.	Blaskets
Scirpus multicaulis,	1	2	3	—	—
,, fluitans,	—	—	3	—	—
,, Savii,	1	2	3	4	5
,, setaceus,	—	—	—	4	5
,, lacustris,	—	—	—	4	—
,, maritimus,	—	2	—	4	—
Eriophorum angustifolium,	—	—	3	—	5
Carex pulicaris,	—	—	3	—	—
,, disticha,	—	—	—	—	5
,, arenaria,	—	2	3	4	—
,, vulpina,	—	—	—	4	—
,, stellulata,	—	2	3	—	5
,, vulgaris,	1	2	—	—	5
,, glauca,	1	2	3	4	5
,, pilulifera,	—	—	—	—	5
,, præcox,	—	2	3	—	—
,, panicea,	—	—	3	—	5
,, binervis,	—	2	3	—	5
,, distans,	—	2	3	4	—
,, extensa,	1	2	3	—	—
,, flava,	—	—	—	4	—
,, lepidocarpa,	—	—	3	—	5
,, œderi,	1	—	—	4	—
,, ampullacea,	—	—	3	—	—
Anthoxanthum odoratum,	1	2	3	4	5
Digraphis arundinacea,	—	—	—	4	—
Alopecurus geniculatus,	1	—	—	4	—
,, pratensis,	—	2	—	—	—
Phleum pratense,	—	—	—	4	—
,, arenarium,	—	—	—	4	—
Sesleria cærulea,	—	—	—	4	—
Agrostis canina,	1	2	3	4	5
,, alba,	1	2	3	4	5
,, vulgaris,	—	2	3	4	5
Psamma arenaria,	—	—	3	—	—
Calamagrostis Epigejos,	—	—	3	4	—
Phragmites communis,	1	2	3	4	—
Aira cæspitosa,	—	2	—	4	—
,, flexuosa,	—	2	3	—	—
,, caryophyllea,	—	2	3	4	5
,, præcox,	1	2	3	4	5
Avena fatua,	—	—	3	—	—
,, elatior,	—	2	3	4	5
Holcus lanatus,	1	2	3	4	5
Triodia decumbens,	1	2	3	—	5
Kœleria cristata,	—	—	3	—	5
Molinia cærulea,	—	2	3	4	—
Catabrosa aquatica,	—	2	—	—	—
Glyceria fluitans,	1	2	3	4	—
,, plicata,	—	—	3	—	—
Sclerochloa maritima,	—	2	—	4	—
,, rigida,	—	—	—	4	—
,, loliacea,	1	—	3	4	5

LIST OF PLANTS.	Tory.	North Aran.	Bofin.	South Arran.	Blaskets.
nua, ...	—	2	3	4	5
atensis, ...	1	—	3	4	5
vialis, ...	1	—	3	—	5
urus cristatus, ...	—	2	3	4	—
lis glomerata, ...	—	2	3	4	5
a sciuroides, ...	—	—	3	—	5
ovina, ...	—	2	3	4	5
rubra, ...	1	—	3	4	5
elatior, ...	—	—	3	—	—
pratensis, ...	—	—	3	4	—
s sterilis.	[illegible]	[illegible]	[illegible]	—	—
mollis, ...	[illegible]	[illegible]	[illegible]	4	5
podium sylvaticum, ...	[illegible]	[illegible]	[illegible]	4	—
m repens, ...	[illegible]	[illegible]	[illegible]	4	5
junceum, ...	[illegible]	[illegible]	[illegible]	4	5
perenne, ...	[illegible]	[illegible]	[illegible]	4	5
temulentum, ...	[illegible]	[illegible]	[illegible]	—	—
s arenarius, ...	[illegible]	[illegible]	[illegible]	—	—
s stricta, ...	[illegible]	[illegible]	[illegible]	—	5
nophyllum unilaterale, . . .	[illegible]	[illegible]	[illegible]	—	5
um Capillus-Veneris, . . .	[illegible]	[illegible]	[illegible]	[illegible]	—
aquilina, ...	[illegible]	[illegible]	[illegible]	[illegible]	5
ia spicant, ...	[illegible]	[illegible]	[illegible]	[illegible]	5
ium Ruta-muraria, ...	[illegible]	[illegible]	[illegible]	[illegible]	—
Trichomanes, ...	[illegible]	[illegible]	[illegible]	[illegible]	—
marinum, ...	[illegible]	[illegible]	[illegible]	[illegible]	5
adiantum nigrum, . . .	[illegible]	[illegible]	[illegible]	4	5
um Filix-fœmina, ...	[illegible]	[illegible]	[illegible]	—	5
ch officinarum, ...	[illegible]	[illegible]	[illegible]	4	—
endrium vulgare, ...	—	—	—	4	—
um angulare, ...	—	—	—	4	—
odium Filix-mas, ...	—	2	3	—	—
dilatatum, ...	1	2	3	4	5
æmulum, ...	—	2	3	—	5
odium vulgare, ...	—	2	3	4	5
nda regalis, ...	—	2	3	—	—
s lacustris, ...	—	2	—	—	—
echinospora, ...	—	—	3	—	—
etum arvense, ...	—	2	3	—	—
hyemale, ...	—	—	—	4	—
limosum, ...	—	—	3	—	—

LXI.—On the Botany of the Galtee Mountains, Co. Tipperary. By Henry Chichester Hart.

[Read, February 14, 1881.]

Having received a grant from the Royal Irish Academy, in 1880, to enable me to examine the Botany of the Galtee Mountains I beg to lay the following results before the Academy:—

Upon the 3rd of August I reached Tipperary, and the following day commenced the detailed exploration of the mountains. My visit, owing to rough weather, was later than I had intended; but the flowering season was not very far advanced when I arrived, and having spent six days upon the range, I do not think it likely that many plants of interest escaped my notice.

The Galtee range extends for about fifteen miles, from Caher at the eastern to Massy Lodge at the western extremity. These mountains form a long ridge, intersected by no transverse valley, and sloping with tolerable evenness to the plains on the south, while they descend with abrupt declivities and a series of cliff-girt tarns to the Vale of Aherlow upon the north. This ridge, which maintains an elevation of above 2500 feet for eight or nine miles, and reaches its greatest height (3015 feet) at Galtymore, about the centre of the range, forms an accurate boundary for the alpine vegetation of the range. Upon the slopes descending southward, though starting from the summit, I met with no alpine or northern type plants; all these, which form its chief botanical interest, lie on the northern face of the mountains.

The geological structure of this backbone of the Co. Tipperary is of Silurian age, with overlying beds of Old Red Sandstone conglomerate, reaching to the summit at Galtymore. The Silurian beds are chiefly a series of clayey and micaceous shales and slate, which form considerable precipices upon the northern side, overhanging and nearly surrounding several mountain lakes. To these favoured spots the alpine vegetation of the mountain is almost entirely confined.

As we go from east to west, we meet with four of these lakes, namely—Lough Curra (1850 feet); Lough Diheen, "Tanyagh" of the natives (1800 feet); Lough Borheen (1700 feet); and Muskry Lough (1500 feet), the numbers after each representing their estimated height above sea-level. Of these, Lough Curra is the most interesting to botanists, as well as being the easiest of access; the cliffs descend from about 1000 feet above, sheer into the water, and around its shores several alpine plants grow luxuriantly. Lough Diheen is the most remote, and the scenery around it is very imposing: this lake and its shores are quite devoid of vegetation—on one side lies a terminal moraine, the relic of an ancient glacier; the water is of

an intensely-dark hue; and the sombre colouring of the lofty cliffs above give quite an arctic character to the scene.

In order to point out to a botanical friend the chief points of interest upon the Galtee Mountains, I would ask him to accompany me upon a long and arduous walk, from Massy Lodge at the western extremity of the range to Caher at the east, and to visit on our way each of the lakes and the cliffs, slopes, and river beds upon either side.

At about 700 or 800 feet above sea-level cultivation has ceased to affect the flora, and we no longer meet with any species introduced by the agency of man. If we ascend Thumpadour, 2570 feet on Ordnance Map, my botanical friend will be no doubt much disappointed at not gathering a single plant of interest. To the east of this summit lies a considerable depression, so that this first point is an isolated outlier of the range. Encouraged by this reflection we cross this valley, and ascend Corrig-na-binnian, 2712 feet. On the way up, *Saxifraga stellaris* is met with; and on the northern bluffs, below the summit, *S. hirta* (vars. *affinis* and *platypetala*), a characteristic plant of these mountains, may be seen. On the northern side of this summit there is a considerable valley, Glan-cush-na-binnian, in which, at about 1500 feet below the summit, *Meconopsis cambrica* may be gathered; it grows here in several places by the stream above Stone Park. Here, too, we find *Scolopendrium vulgare*, a couple of plants by a waterfall, the only place it appears to occur on the mountains; *Carex ovalis* also grows in this valley, elsewhere met with only at Lough Muskry, and below Lough Curra. Advancing eastward from the last summit to the heights above Lough Curra, and descending about 200 feet on the north of the ridge, we may gather *Hymenophyllum tunbrigense;* and on cliffs a little below the point marked 2544 feet on the Ordnance Map, about half a mile west of Lough Curra, we first meet with *Asplenium viride* and *Cystopteris fragilis*. These two ferns become abundant and luxuriant around and above Lough Curra. In one place here, too, grows the rare *Arabis petræa*, whose only previously-known habitat in Ireland is Glenade Mountain, in Co. Leitrim. It grows here in small quantities upon one bluff, facing east of north, at an altitude of about 2600 feet, above and to the west of Lough Curra. There were neither flowers nor pods upon this scarce little crucifer, but a comparison with living specimens in the College Botanic Gardens enabled me to identify the plant. This was the most interesting plant observed upon the Galtees.

Besides the species already named, several other alpine plants abound around Lough Curra, especially at and for about 100 feet above the lake—as *Oxyria reniformis*, *Sedum Rhodiola*, *Saxifraga stellaris*, *Cochlearia officinalis* (var. *alpina*), and in smaller quantities *Hieracium anglicum*. The lake itself contained no aquatic plants, except *Litorella lacustris*—not even *Callitriche hamulata*. These cliffs are more alpine in character than those around the other lakes, contain-

ing, as they do, the greatest number of alpine and the smallest of lowland plants. Lough Curra is easy of access, and will well repay a visit.

From here we will make a descent by the stream from the lake to the borders of cultivation at about 750 feet, noting the heights at which the more lowland species begin to appear, and reversing the process upon our return, so as to obtain the lower limits of the alpine species. Upon this detour, we meet with *Pinguicula lusitanica* and *Drosera rotundifolia* sparingly, in one place at an altitude of 850 to 900 feet; these were not met with elsewhere upon the Galtee range, and the rarity of plants so frequent on Irish mountain ranges seems unaccountable. The results of these observations will be found in the appended list; but it may be mentioned here, that none of the alpine plants, except *Saxifraga stellaris*, descend below the levels of the cliff-bases, corresponding with the altitudes of the lakes given above.

Having examined the attractive, though dangerous, precipices of Lough Curra, and the high ground above, as well as the northern slopes below, we will take a botanical survey of the southern descent towards Mitchelstown. Once the ridge is crossed and we face downwards, we meet with a gradually-diminishing mountain flora of the commonest type, which, as far as my observations went, contained no remarkable plant. Four distinct excursions upon this southern aspect of the Galtees led me to this conclusion; we will, therefore, resume our course at Lough Curra, and pursue it in an easterly direction.

Having crossed a spur running north from Dawson's Table (Galtymore), we came upon Lough Diheen (1800 feet)—a small and perfectly barren tarn sunk in a cradle of glacial drift. This lake is about three parts surrounded by precipices, which do not quite reach the water, and is fringed with piled moraine matter in a barrier about 20 to 30 feet high. To the student of ice-action this lake will be of interest, but to explore the botany we must scramble up amongst the precipices. Keeping upward towards Galtymore, and examining the different ledges on the faces of the cliffs, we notice merely a diminution in the flora, and find nothing of much interest until within about 400 feet of Galtymore. Here is a small patch of the rare *Saussurea alpina*, consisting of but four or five plants. This plant has been hitherto known only from two places in the Kerry mountains, and was recently rediscovered by me in the Co. Donegal. We will leave these few roots undisturbed. Many lowland plants abound here at an unusual height. *Chrysosplenium oppositifolium* and *Montia fontana* are very plentiful within 200 feet of the summit, and *Rhinanthus Crista-galli* occurs at an altitude of about 2400 feet. As we still travel east from Lough Diheen, and examine the bases of the wet bluffs and north-looking cliffs, we again notice *Asplenium viride* and *Oxyria reniformis*, though decreasing in quantity. *Saxifraga hirta*, vars. *genuina*, *platypetala* and *affinis*, also occur, the last two being the most abundant. At an altitude of about 2600 feet north of Lough Diheen, *Salix herbacea* also appears; it occurred previously

in one place about 20 feet below the summit of Galtymore, and ranges eastward from that to the Muskry cliff. This alpine plant chooses the cracks and fissures in bare and wind-blown summits, despising the moisture and shelter which the others seem to require. After a few more hours' climbing we come in view of Lough Borheen (1700 feet). The vegetation around this lake is less alpine in character than that of the others, and around its shores many fresh lowland species occur, as *Bellis perennis*, *Trifolium pratense*, *T. arvense*, Leontodon, Taraxacum, &c. At the northern corner, and down to the level of the lake, *Asplenium viride* and *Saxifraga hirta*, var. *platypetala*; and here, for the first time, we gather the London Pride Saxifrage (*Saxifraga umbrosa*), which is a truly alpine plant upon the Galtee range, although it does not extend westward to Galtymore. Eastward of Lough Borheen it becomes abundant; near this lake, too, about a quarter of a mile east, we find *Vaccinium Vitis-idæa* for the first time. It appears again at Lough Muskry.

Having explored this coomb and its surroundings, we will pursue our line of march, keeping along the high ground which breaks at length into the magnificent range of cliffs above Lough Muskry. I spent a long day climbing amongst their numerous clefts and ledges, the cliffs themselves towering to a height of about 1200 feet in vast verdant walls and terraces to the north and north-east of the lake. With the exception of Arabis and Saussurea, the alpine plants reappear here in great profusion. Two rarities seem peculiar to these cliffs, *Thalictrum minus* and *Geum rivale*, occurring up to 2000 feet. The most-finely cut leaved form of *Saxifraga hirta* (i. e. var. *genuina*) is very abundant here, forming in some places the entire green sward at the base of the cliffs. Several plants also reach an unexpected altitude above Lough Muskry. *Carex paniculata* grows at the level of the lake (1500 feet), and above it to a height of 1900 feet. Other lowland plants not before gathered occur around its shores, amongst which a remarkably starved form of *Polygonum hydropiper* may be mentioned.

We will make a descent from here into the Vale of Aherlow, and repeat the same observations upon the upper and lower limits of the two groups of plants, lowland or mountain. On this part of the Galtees we gather *Sarothamnus scoparius* and *Lastrea æmula*, on the borders of an extensive plantation, at about 800 feet altitude. The fern is scarce on the Galtees, but it occurs also on the southern side at about 1200 feet. A few other plants of no special interest are added to the list; and bearing upwards and to the east again, we will follow the range, down to Caher. Along the crest of the cliffs above Lough Muskry, at about 2600 feet, *Empetrum nigrum*, *Lycopodium selago*, *Saxifraga stellaris*, and *S. umbrosa* occur: soon these latter three disappear, and the usual mountain plants are alone to be met with. The eastern extremity of the range is very barren; some points and a considerable extent on their flanks being entirely free from vegetation—a desolate waste of sandstone and conglomerate *débris*.

At Slieve Anard (1457 feet), *Pteris aquilina* occurs, about 100 feet below the summit—a remarkable altitude for this fern; and at 1250 feet *Ulex Gallii* and *U. europæus* appear together—an unusual height at which to meet either kind of furze. Nothing worthy of mention will be met with at this extremity of the range, which descends gradually into the plain of Tipperary.

The foregoing is a sketch of the ground gone over and observations taken during six consecutive days, which I divided as follows:—*First day* (August 4)—From Tipperary to Lough Curra, examined shores and cliffs about lake; reached summit of Galtymore, and walked down to Mitchelstown. This day it never ceased pouring rain. *Second day*—From Mitchelstown by the mountain lodge to the ridge above Lough Borheen, making many detours on the southern slopes; examined shores and cliffs of this lake, and travelled westward along cliffs above Lough Diheen to a further examination of Lough Curra; walked into Tipperary. *Third day*—Up by Knockmoyle and other summits to Lough Diheen; climbed cliffs and ravines to the north of the lake, and along ridges, and all the range down to Massy Lodge at its western end, home to Tipperary. *Fourth day*—Up to Lough Curra again, to examine some ravines not previously searched, and then explored eastwards along the range to Caher. This was a dreadful day on the mountains; storm and rain from start to finish. *Fifth day*—Up the northern side from near Castlemary (about half way between Tipperary and Caher), through an extensive plantation to Lough Muskry; spent the day amongst the precipices there, and had much severe climbing; walked into Tipperary. This was a long and successful day's work. *Sixth day*—Up by Stone Park, through Glan-cush-na-binnian, and along ridge to Loughs Curra and Diheen, and home to Tipperary; a very wet afternoon, and there seemed nothing left that required exploration; so that I concluded my labours with this walk. Thus I hope that I explored the range completely, with the exception of the lowland portions, especially on the southern side. An accident, which I much regretted, was the breaking of my aneroid, and I was deprived of its use until two days before leaving. However, on the last day, I verified many points which I had before estimated from the heights given on the Ordnance Map, and I took many observations of points by which to check my previous notes. I cannot refrain from mentioning here what a misfortune it is that the southern counties are not marked with the contoured lines of elevation on the Ordnance Maps, as the northern are. It seems very strange that at present there is no means, from any map, of finding the altitudes of such well-defined bases for observation as mountain lakes, or indeed of any points except the marked summits. There are four mountain lakes (some of considerable size) on the Galtee range, and yet there is no record in the Ordnance or Geological Survey Offices of the heights of any one of these lakes above sea level. This was a condition of affairs I had not foreseen; and had I known I was to be entirely dependent upon my aneroid, I should

have taken care to have provided myself with a spare one. Even so, however, some authenticated observations by the officers of the Survey would be desirable as a check.

In summarizing the results of my observations, I wish first to mention that my friend A. G. More agrees with me that a slight alteration in the relative boundaries of Districts 6 and 2 of the Cybele Hibernica would be advantageous. As the map there stands, the Galtee range enters into both these districts; and I would suggest that the part of District 6 which includes a small western portion of the Galtee range be joined to District 2. The road running south, from Galbally to Ballyarthur, would form a good natural division, and in this way the whole Galtee range is included in District 2. A glance at the map will show that this is a natural division.

The following is a list of the alpine plants, ten in number, found upon the Galtees—all of these belong to Watson's Highland type:—

Arabis petræa.	*Vaccinium Vitis-idæa.*
Sedum Rhodiola.	*Oxyria reniformis.*
Saxifraga stellaris.	*Salix herbacea.*
Hieracium anglicum.	*Asplenium viride.*
Saussurea alpina.	*Cochlearia officinalis* (var. *alpina*).

This alpine flora is below the average for Irish mountain ranges, and this is the more remarkable when the elevation of the Galtymore chain is considered. In fact, with the exception of the Wicklow mountains, the highest point of which is a few feet higher than Galtymore, the Galtees yield the poorest flora of any range in Ireland. On the other hand, they can carry up many lowland species to an unusual altitude. Another feature in the flora of this range is worthy of notice—the extreme rarity, or entire absence, of many common Irish mountain plants. It is, of course, unsafe to say that any species not observed is really absent, but I can safely say that the following are very rare or wanting:—*Drosera rotundifolia, Pinguicula lusitanica*, mountain Hieracia of all kinds, *Myrica Gale, Isoetes lacustris, Antennaria dioica, Juniperus communis.* Of these, the last four were not met with at all.

Of Watson's Scottish or Northern type only three species occur: *Thalictrum minus, Saxifraga hirta, Crepis paludosa*, a very small proportion of the Irish species (66). But this might have been expected, from the southern position of the locality.

The following are additions to District 2 of the Cybele Hibernica:—

Thalictrum minus.	*Pyrus aucuparia.*
Arabis petræa.	*Saussurea alpina.*
Polygala depressa.	*Myosotis repens.*

The occurrence of *Meconopsis cambrica* and *Hieracium anglicum* upon this range, as giving new localities for two rare Irish plants, although each had one previous station in the district, is important.

As the districts stand at present, *Carex ovalis* is an addition to District 6, but I prefer to include it in District 2.

There are three tolerably distinct forms of *Saxifraga hypnoides* to be met with on the Galtee range. Following the names given in Syme's English Botany, these seem to be *S. hirta*, var. *genuina* and var. *affinis* and *S. eu-hypnoides*, var. *platypetala*. All may be met with in various parts of this range, and to a considerable extent, irrespectively of altitude; but *S. affinis* is the form usually to be found at the greatest heights: *S. platypetala* in the wetter and mossy places by streams at lower levels; while *S. hirta*, var. *genuina*, the finest-cut form with bristle-pointed leaves, is especially characteristic of the bases of the loftier cliffs, as at Lough Muskry. *S. hirta* of the Galtees is much less hairy than the Donegal plant found by me on Aranmore;[1] but in other respects they are, I believe, identical.

My experience of these Irish Saxifrages and of the innumerable arctic forms of *S. cæspitosa* leads me to believe that an unbroken chain from the extreme forms of *S. hypnoides* to those of *S. cæspitosa* might be enumerated which would defy division. But it is unfortunately necessary to have names for forms belonging to different countries.

In conclusion, I have to acknowledge my obligations to Mr. Backhouse, who kindly examined some Saxifrages and Hieracia; and to my friend Mr. A. G. More, who has, as usual, afforded me every assistance in his power.

General list of the Plants observed on the Galtee mountains, arranged in descending order. This arrangement has been adopted for the convenience of comparison with other mountain ranges. Special localities or other remarks will be found given in the introductory remarks. The alpine and most characteristic plants are printed in italics.

Summit of Galtymore.

3015 feet.

Galium saxatile, Linn.
Calluna vulgaris, Salisb.
Rumex Acetosella, Linn.
Agrostis vulgaris, With.
Aira flexuosa, Linn.
Festuca ovina, Linn.

3000 feet.

Stellaria uliginosa, Murr.
Saxifraga stellaris, Linn. (to 1200 feet).
Chrysosplenium oppositifolium, L.
Vaccinium Myrtillus, Linn.
Rumex Acetosa, Linn.
Salix herbacea, Linn. (to 2200 feet).
Luzula sylvatica, Beck.
Eriophorum vaginatum, Linn.
Poa annua, Linn.

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[1] See *Journal of Botany*, January, 1881.

2850 feet.

fontana, Linn.
lla Tormentilla, Schenk.
eris fragilis, Bernh. (to feet).
Asplenium viride, Huds. (to 1500 feet).
Lastrea Filix-mas, Presl.

2650 feet.

Arabis petræa, Lam. (in one place only).

2600 feet.

› Virga-aurea, Linn.
ea alpina, D. C. (only sta-
um nigrum, Linn.
Oxyria reniformis, Hook. (to 1500 feet).
Carex stellulata, Good.
Lycopodium Selago, Linn.

2570 feet.

Saxifraga hirta et vars. (to 700 feet).

2500 feet.

lus Flammula, Linn.
ine pratensis, Linn.
um triviale, Link.
um palustre, Linn.
Rhodiola, D. C. (to 1850
ga umbrosa, Linn. (to 1750
a sylvestris, Linn.
lon autumnalis, Linn.
Crepis paludosa, Moench.
Jasione montana, Linn.
Campanula rotundifolia, Linn.
Juncus squarrosus, Linn.
Carex vulgaris, Fries.
Lomaria spicant, Desv.
Hymenophyllum Tunbrigense Sm.
Lastrea dilatata, Presl.

2400 feet.

hyllum sylvestre, Linn.
ia officinalis, Linn.
thus Crista-galli.
yrum pratense, Linn. montanum).
Euphrasia officinalis, Linn.
Carex flava, Linn.
Polypodium vulgare, Linn.

2200 feet.

um Vitis-Idæa, Linn. (to feet).
valis, Good.
C. binervis, Sm.
Poa pratensis, Linn.
Asplenium Trichomanes, Linn.

2150 feet.

Erica cinerea, Linn.

2100 feet.

dia, With.
purpurea, Linn.
Anthoxanthum odoratum, Linn.

2000 feet.

trum minus, Linn. (only
ion).
ia officinalis, Linn. (to
et).
istris, Linn.
ericum pulchrum, Linn.
Oxalis Acetosella, Linn.
eum rivale, Linn. (only station).
yrus aucuparia, Gært.
ieracium anglicum (to 1900 feet).
edicularis sylvatica, Linn.
Luzula campestris, D. C.

1950 feet.

Veronica officinalis, Linn.
Pteris aquilina, Linn.

1900 feet.

Epilobium montanum, Linn.
Scabiosa succisa, Linn.
Primula vulgaris, Huds.
Carex paniculata, Linn.

1850 feet (Lough Curra level).

Stellaria Hnolostea, Linn.
Alchemilla vulgaris, Linn.
Litorella lacustris, Linn.
Juncus supinus, Moench.
Agrostis vulgaris, var. pumila, With.

1800 feet.

Ranunculus Ficaria, Linn.

1750 feet.

Cardamine hirsuta, Linn.

1700 feet (Borheen Lake level).

Ranunculus repens, Linn.
R. acris, Linn.
Lychnis diurna, Sibth.
Trifolium repens, Linn.
Rubus Idæus, Linn.
Callitriche platycarpa, Scop.
Bellis perennis, Linn.
Veronica serpyllifolia, Linn.
Ajuga reptans, Linn.
Prunella vulgaris, Linn.
Lysimachia nemorum, Linn.
Potamogeton natans, Linn.
Carex glauca, Scop.

1600 feet.

um Robertianum, Linn.
tuberosus, Linn.
discolor, W. L. N.
us Oxyacantha, Linn.
Helix, Linn.
ra Periclymenum, Linn.
Taraxacum officinale, Wigg.
Erica Tetralix, Linn.
Teucrium Scorodonia, Linn.
Salix caprea, Linn.
Orchis maculata, Linn.

1500 feet (Muskry Lake level).

palustris, Linn.
catharticum, Linn.
um palustre, Linn.
Ulmaria, Linn.
che verna, Linn.
uliginosum, Linn.
go Farfara, Linn.
vulgaris, Linn.
is repens, Don.
Polygonum Hydropiper, Linn.
Potamogeton polygonifolius, Pour.
Triglochin palustre, Linn.
Narthecium ossifragum, Huds.
Juncus acutiflorus, Ehrh.
Carex præcox, Jacq.
C. ampullacea, Good.
Nardus stricta, Linn.

1400 feet.

ia vesca, Linn.
Scolopendrium vulgare, Sm. (only station).

1350 feet.

ia graminea, Linn.

1300 feet.

psis cambrica, Linn., big.
200 feet).
cum Androsæmum, Linn.
y station).
Veronica agrestis, Linn.

1250 feet (Slieve Anard).

uropæus, Linn.
Ulex Gallii, Planchon.

1200 feet.

Flos-cuculi, Linn.
procumbens, Linn.
orniculatus, Linn.
racca, Linn.
Sanicula europæa, Linn.
Carduus palustris, Linn.
Scirpus setaceus, Linn.
Lastrea æmula, Brack.

1000 feet.

atense, Linn.
vulgaris, Linn.
ticus, Huds.
alustris, Linn.
Scirpus palustris, Linn.
Molinia cærulea, Mœnch.
Equisetum sylvaticum, Linn. (only station).

900 feet.

sera rotundifolia, Linn.
epium, Linn.
lutetiana, Linn.
Veronica scutellata, Linn. (only station).

t.

Pinguicul ca, inn. (only station).

800 feet.

Viola sylvatica, Fries.
Polygala vulgaris, Linn.
P. depressa, Wender.
Lotus major, Scop.
Sarothamnus scoparius, Koch.
Helosciadium nodiflorum, Koch.
Senecio jacobæa, Linn.
Hypochæris radicata, Linn.
lantago lanceolata, Linn.
nagallis tenella, Linn.
uncus effusus, Linn.
Juncus bufonius, Linn.
Aira cæspitosa, Linn.
. caryophyllea, Linn.
olcus lanatus, Linn.

700 to 600 feet.

Ranunculus hederaceus, Linn.
Hypericum humifusum, Linn.
Prunus spinosa, Linn.
Gnaphalium uliginosum, Linn.
Rumex nemorosus, Schrad.
P. aviculare, Linn.
And many weeds of cultivation.

LXII.—ON HALOS AND ANTHELIA. By PHILIP BURTON.

[Read, November 30, 1880.]

THE formation of those luminous circles termed halos, and of the other appearances which sometimes accompany them, is now universally attributed to the action of icy particles suspended in the air—an opinion which seems to have been first entertained by Descartes, and was afterwards established by Mariotte and Dr. Young. Of all these appearances, the halo of 22° distance from the sun is the only one which occurs frequently in these countries; it may be said, indeed, to be a very common phenomenon usually preceding changes of weather. Its formation is exemplified by bringing filaments of hoar-frost very near the eye in sunlight, when colours corresponding to those of the halo will appear at the same elongation. A similar circle is seen less frequently at the distance of 46° from the sun, and, according to Cavendish, is produced by the ends of the crystals when they are regularly formed. Parhelia, or "mock suns," occasionally occur about the places where these halos are intersected by horizontal and vertical circles passing through the sun; these are, also, explicable on principles suggested by Mariotte. But other halos have been described which are not so easily accounted for. Thus, on the 1st of December, 1819, Captain Parry observed one which surrounded the moon at a distance of about 38°, and was accompanied by paraselenæ, and it does not appear evident why such phenomena should occur at this particular elongation.

On the 6th of March, 1869, I observed a circular halo smaller than any of the preceding, its semi-diameter, as I considered, not being greater than 10° or 12°. Its colours were in the usual order, the red being next the sun, and it was visible for more than two hours. It could not have been a corona, as such a phenomenon can seldom be seen unless when reflected from water, being generally too faint to be otherwise perceived, whereas in the present instance the halo was very bright. The part of the sky where it occurred was free from clouds, though presenting a sort of hazy appearance; and the estimate which I made of the diameter of the circle showed it to be about half that of the common halo. As calculation shows that prisms of ice whose bases are regular pentagons would produce a halo similar to the ordinary one, and at the distance of 11° 46′ from the sun (which very well agrees with the estimated position), it appears very probable that this circle must have been formed by such crystals. And that water may sometimes be frozen in particles of that shape, I have no doubt, having on one occasion seen a shower of hail which consisted entirely of pentagonal prisms. These were perfectly formed, of a whitish colour, and nearly opaque, and were remarkable for their shortness in comparison

with the diagonals of the bases, thus presenting the appearance of pentagonal plates.

Some varieties of cirrus clouds, though doubtless composed of frozen particles, do not exhibit halos. These are of a whitish colour, and are probably more or less opaque; sometimes, also, they may consist of particles having a globular form (like small snow or hail), which would explain the absence of coloured rings. During a balloon ascent from Paris in 1874, MM. Albert and Gaston Tissandier passed through a zone of ice crystals which extended through a depth of 200 metres, and presented the appearance of a "galaxy of little hexagonal stars;" yet as no coloured circles are mentioned as having been seen, it is to be presumed that they were not visible. In this instance, therefore, the crystals must have been either partly opaque or irregularly formed.

Bright specks of halo appearing at a greater distance from the sun than the parhelia above mentioned are called anthelia. These are of rare occurrence, and though I looked for them on several occasions which I thought favourable to their appearance, I have not discerned them in any instance. Three positions are usually assigned to them, the first being about 90° from the sun. In reference to this appearance Dr. Young says: "The lateral anthelia may be produced by the rays refracted after two intermediate reflections, which will have a constant deviation 60° greater than those which form the halo. These anthelia ought, therefore, to be about 82° from the sun. They are, however, usually represented as much more distant." The explanation here given is doubtless correct; but there seems to be a mistake in assigning 82° as the distance from the sun, that quantity being not the greatest deviation, but its supplement. If x and z be the angles made by the incident and emergent rays with perpendiculars to the respective surfaces, and $I =$ the refracting angle of the prism (not regarding the signs of the angles, and supposing also that in the progress of a ray each change of direction is made from one surface of the prism to the next in succession which is inclined to it at an angle equal to I), then the deviation after two refractions and two reflections will be $3I - (x + z)$. For hexagonal prisms this becomes $180° - (x + z)$, the maximum value of which (corresponding to index 1·31) is 98° 10′. The part of the light which is differently reflected does not form an anthelion at any deviation whatever. Hevelius and others have given 90° as the distance of the anthelia observed by them; but these instances are not conclusive, as the elongations seem to have been merely estimated, and not obtained by measurement.

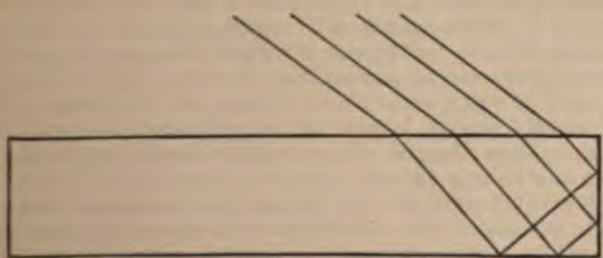
The other positions of the phenomena are mentioned in the following statement:—"The anthelia seem to be referrible to two refractions and an intermediate reflection within the same crystal, causing a deviation of about $120 + 22 = 142°$; and sometimes with two intermediate reflections producing an angle of $60 + 22 = 82°$ only. It is not very easy, however, to assign a reason for the appearance of an anthelion exactly opposite to the sun, which is said to have been sometimes seen in the horizontal circle."—(*Encyclopædia Britannica*, vol. vi., p. 645.)

Here it is evident that the deviation, 142°, has been calculated for rays whose paths within the crystals make equal angles with the surfaces, but no reason has been adduced to show that these could form an anthelion or halo. When light is once reflected in any regular prism (in the manner before mentioned), the deviation is $180° - 2I + (x + z)$, which, since in this case z is always equal to x, reduces to $180° - 2I + 2x$. Now, as this quantity must vary twice as fast as x, it cannot tend to become constant for any successive values thereof; from which it follows that there cannot be at any point such a spissitude of the homogeneous rays as is always requisite to form halos. Thus it appears that no halo or anthelion can be caused by light which has been only once reflected.

An anthelion not differing much from the assigned position would be produced by two refractions and two reflections in quadrilateral prisms having right angles. The deviation in this case is $270° - (x + z)$, which, when a maximum, gives 134° 16′, the elongation of the anthelion formed by such crystals; hence it appears probable that the phenomena seen near this position were produced by rectangular prisms, or by the ends of the usual hexagonal ones.

If the colours of these phenomena were observed, their order with respect to the sun would sufficiently indicate whether they were formed by rays directly transmitted, or after two reflections. In the former case it is evident that the deviation must be a minimum, and in the latter a maximum, and the colours of the reflected anthelion will be the reverse of those usually seen in halos; but I have not found them described in any instance.

The third anthelion which appears opposite to the sun has not been explained; but it seems possible that a phenomenon of this kind may sometimes be produced by part of the light which has been twice reflected in rectangular prisms. If at each change of direction a ray passes from one surface of such a prism to the next, or again, if the



reflections be made at the two opposite surfaces which are adjacent to that at which the light was first incident, the deviation will be $3I - (x + z)$ as before. But it is easily seen that a portion of the light may be so transmitted that after the second reflection it will again fall

face at which it entered the crystal, the rays then emerg-
l lines. In this case it is evident that the deviation is
equal to 180°; hence, whatever be the angle of incidence,
ll return in the same direction, and thus an indefinite
ystals will contribute to the formation of an anthelion
e sun. This may happen whether the principal section
be square or oblong, and it may also take place in hexa-
s, since a section of any of these made by a plane perpendi-
o opposite surfaces and to the bases will have the form of
g. But as the position of the anthelion thus formed would be
ar the antisolar point, it could only occur at a low altitude;
e it would not explain the appearances which have been seen at
derable heights. Mr. Barker described one seen near Lake
ior, which had an altitude gre r than 45°, or above twice that
sun (*Philosophical Transaction* or 1787, p. 44). The horizontal
which was in that instance high is usually represented as
passing through the sun.

LXIII. ABNORMALITIES IN HUMAN MYOLOGY. BY J. F. KNOTT, F.R.C.S.I.

[Read, April 11, 1881.]

THE following is an imperfect list of the muscular anomalies which have come under my notice during the four winters which I have occupied the office of Demonstrator of Anatomy in the School of the Royal College of Surgeons. During that time I have paid particular attention to some of those which struck me in the commencement as being specially important or interesting, and which attracted my attention sufficiently to induce me to tabulate the frequency of their occurrence. As I had not the advantage of any co-operation in the research, a very large proportion of the anomalies which might easily have been preserved were necessarily lost, from the fact that it was impossible for me to distribute my attention over the dissection of so large a number of subjects as were always passing through the room. My statistics are, accordingly, in many instances, very imperfect, although by no means so, I hope, in all; but, although not so valuable as could be desired as an index of frequency, I venture to hope that the publication of the present collection will be found interesting to those who have devoted any attention to this special department of Anatomy. The importance attached to these variations must daily increase in connexion with the absorbing interest of the study of muscular morphology, and of the homologous elements thereof in the various grades of the animal kingdom. Viewed from this standpoint, an otherwise somewhat dry catalogue of variations in Human Myology will be looked upon with favour by those who hail with welcome the addition of every small contribution to the hourly increasing treasury of our knowledge in this, one of the most interesting departments of human study.

Occipito-frontalis.—The early removal of the brain prevented me from examining this muscle completely, in a large proportion of the subjects of our dissecting-room. The frontal portion I have seldom found to agree completely with the description given in our standard text-books. I have noted its peculiarities in twenty-eight cases, in which I examined it with special care. In only five of these did the fleshy fibres reach so high as the coronal suture. Below I have always found its fibres attached to the internal angular process of the os frontis, some being continued into the pyramidalis nasi, and levator labii superioris alaeque nasi, but the great bulk of the fibres blended with the orbicularis palpebrarum and corrugator supercilii, and a large proportion adhered to the deep surface of the skin of the eyebrow. I could never satisfy myself of an attachment of any of its fibres to the nasal bone, glabella, superciliary ridge, or supraorbital arch, as has been described by different observers. In every case I examined, the deep surface of the muscle appeared to glide freely over those bony prominences, and to be connected thereto

Of the *occipitalis* muscle I have seen union of those c
sides in two instances, and decussation of the lower fibres i
Transversus nuchae (F. E. Schultze).—Was present on b
five of the twenty-eight bodies, and on one side only in two o
muscle is said to be always symmetrical, but in the latte
I could find no muscular fibres on the opposite side, b
transverse tendinous band took its place. The attachn
the same in all: from the external occipital protuberan
inside, to the posterior border of the sterno-cleido-mastoid
its insertion; while a few fibres were attached separat
superior curved line of occipital bone above the others.

Of the muscles of the ear, intrinsic or extrinsic, alt
quently examined, I have not noted the variations with any

Retrahens aurem.—This muscle I have seen usually for
very distinct slips, and somewhat less frequently of three
condition which was looked upon by Albinus as the norm
ment (*tres retrahentes auriculam*). The lowest of the three
have found arising in two instances from the cervical fasc
upper part of the sterno-cleido-mastoid muscle. In a few c
the bundles was found replaced by a tendinous band.

Attollens and *Attrahens aurem* I have frequently fou
at their adjacent edges so as to form one continuous plane c
fibres, as described by Cruveilhier (*muscle auriculaire s*
auriculo-temporal). The origin of attrahens aurem from t
described as normal by Wharton, Jones, and Harrison, I
with in eight cases. Cruveilhier describes this as a disti
under the name of *muscle auriculaire anterieur profond*, who
attachment is into the external surface of the tragus.

The intrinsic muscles of the auricle have so often el
tempts to define them, that I do not think I succeeded in a
in demonstrating the presence of all of them in the same su

Depressor auriculae (Lauth); *stylo-auricularis* (Hyrtl
muscle I found one example. In three other cases I v
define a well-marked fibrous cord, having the direction
ments presented by the muscular fibres when present. In

twice seen. In one case the origin of the anomalous bundle of muscular fibres was in common with the levator palpebrae superioris, and the insertion into the fibrous pulley for tendon of superior oblique (*rectus quintus* of Molinetti; *tensor trochleae* of Budge).

Depressor supercilii (Lesshaft); *depressor palpebrarum* (Arlt); *lachrymalis anterior* (Henke).—Of this muscle the fibres were found moderately well developed in two cases out of seven in which it was looked for. In the others it was almost completely absent: a few fibres were found with difficulty in two of them.

Depressor palpebrae inferioris (Caldani).—This muscle, which seems to be a continuation of some of the fibres of the platysma myoides, I have been able to define clearly in five out of eighteen cases in which it was searched for, the upper extremity being attached to the lower fibres of the orbicularis palpebrarum.

Orbicularis palpebrarum.—A slip from this muscle to the levator palpebrae superioris is described by Henle and noticed by Professor Macalister. I consider it to be a not uncommon arrangement, as I have found it developed in a considerable number of instances, although I did not take any note of the proportion. The origin of the zygomaticus minor from the lower fibres of the orbicularis I have twice observed.

Levator labii superioris.—The only deviation from the usually accepted description of this muscle which I have met with is the tricipital arrangement described by Eustachius, the outer coming from the malar bone (*caput zygomaticum, jochbeinzacke* of Henle). This bundle of fibres was well developed in about one-third the cases examined.

Depressor septi mobilis narium (Meyer, Krause), *depressor apicis naris, nasalis labii superioris, nasolabialis*—looked upon by many as merely a septal attachment of the *orbicularis oris*, has been more correctly described by Meyer as a separate muscle of triangular form. The base is below, blending with the upper fibres of the orbicularis oris, and apex above, attached to the lower border of the septal cartilage.

Risorius (Santorini).—The typical arrangement of the fibres of this muscle—from parotidean fascia to angle of mouth, blending with orbicularis oris—is met with in a large proportion of cases. The fibres in their inward course pass superficial to those of the platysma myoides, and form with the latter an acute angle. The risorius of most of our text-books of the present day is derived from the platysma itself, but the description is I think rather a loose one, and not borne out by the results of careful repeated examination. Rarer origins have been described—from the zygoma (M'Whinnie); external ear (Albinus): fascia over upper third of sterno-cleido-mastoid (Hallett); an accessory head from transversus nuchae (F. E. Schultze)—of each of these I have met with examples.

Transversus menti (Santorini); *faisceau sous-symphysien* (Cruveilhier).—This band of muscular fibres prolonged from the antero-internal part of the triangularis menti, meets a similar one from the opposite side in the mesial line. On its presence the existence of a "double-chin" depends. I have found it in three cases out of eleven in which it was

searched for. From its peculiar action on the contour of t
tal region, it has been called by German authors the *doppe*

Masseter.—The only anomaly I noticed in connexio
muscle was a coalescence of its deeper fibres with the lov
the temporal. This condition has been also observed b
Macalister, and I have met with it three times. The *bu
rica* described by Monro between the two parts of this mu
failed to find, although I have carefully examined the mu
special purpose in thirty subjects. Of the bursa describ
between the deep part of the muscle and the capsule of th
maxillary articulation I have met several examples.

Buccinator.—A few fibres of this muscle I have seen t
Steno's duct in three instances.

Pterygoideus proprius (Henle, Gruber, Theile, Maca
this muscle I have met with three examples in one hundred
bodies, passing as usual from the crest on the great wing
to posterior edge of external pterygoid plate.

Sterno-cleido-mastoideus.—Of this muscle I have met
anomalies, in some cases completely divided into sterno-m
cleido-mastoid: of this I have met with eleven examples.
mastoid I have found in three cases divided into two comp
rate superimposed laminae, distinct to the mastoid attachme
cases I have seen the upper sternal fibres of the pectoralis m
an accessory tendinous origin from the outer edge of the s
of this muscle.

Levator claviculae (Wood).—Of this muscle I have see
well developed specimen attached at its upper end to ant
cles of transverse processes of second, third, and four
vertebrae, and below to the middle third of upper border
outside the cleido-mastoid.

Coraco-cervicalis (Krause, Hallett).—Of this muscle, v
other than the posterior belly of omo-hyoid terminating in
fascia—when the anterior belly is absent—I have met with
ples. I have in another case traced a small aponeurotic sl
upper edge of the tendon formed by posterior belly of omo-h
the normal course of anterior belly to the body of the hyoi

Omo-hyoid.—Of the origin of the posterior belly of t
from the coracoid process I have met with seven examp
hyoid of Gruber). In one case the origin of this belly w
acromion process. (Origin from first rib as described by V
Gruber I have never seen.) Of the purely clavicular ori
met with two specimens; in each case the muscle was mono
presented at the level of the normal tendon merely a few l
tendinous fibres on its deep surface (*cleido-hyoid* of Schm
In addition to the variations above described under the h
musculus coraco-cervicalis I have found in two other cases t
belly represented by *two* distinct tendinous slips passing fro
mal tendon up to body of hyoid bone.

Crico-corniculatus (Tourtual): *kerato-cricoid* (Merkel):

ideus posticus (Bochdalek).—Of this muscle I have found seven es of unilateral development, and two others in which its fibres re symmetrical.

Crico-epiglotticus.—Under this name has been described a bundle of scular fibres often found (thirty-four per cent., Krause) arising from inner surface of cricoid cartilage, and passing upwards beneath the cous membrane to the margin of the epiglottis. I have been able lefine it three times in nineteen subjects. It was bilateral in each e. Sometimes a similar bundle terminates in the arytaeno-epiglotti-n fold of mucous membrane forming a crico-membranosus.

Crico-trachealis.—Of this anomalous muscle I have met with one cimen on the left side of the body of a female subject. It came n lower border of cricoid cartilage, approaching close to the median in front, and having a breadth of about half an inch above; it dually narrowed as it passed down to its insertion into the fourth fifth rings of the trachea behind the isthmus of the thyroid body.

Thyreo-trachealis (Gruber); *thyreo-trachealis profundus* (Krause).—m lower border of thyroid cartilage to upper part of trachea. This d of muscular fibres I found three times in twenty-eight subjects in ich its existence was specially searched for. The muscle was sym-rical in one case; in the others single; in both on left side. The rior attachment varied in all. In one case the insertion was into third ring of the trachea; in another into third and fourth. In the in which the muscle existed on both sides the insertion was into fourth and fifth rings on one side (the left); on the other into fifth ring alone.

Thyreo-syndesmicus (Sömmerring).—From superior corner of thyroid tilage to posterior border of thyro-hyoid ligament. In one subject ound this small anomalous band of muscular fibres present on both s. I have met with no other example.

Thyreoideus transversus anomalus (Gruber) (s. *impar*); *thyreoideus ginalis inferior; incisurae (cartilaginis thyroideae) mediae transver-*.—This band of muscular fibres crosses from one side of lower border ila of thyroid cartilage to the other, lying in front of the upper part he crico-thyroid membrane. I have met with two examples.

Thyreo-corniculatus.—Fibres arising in common with the upper fibres hyreo-arytaenoideus, and passing obliquely upwards and backwards he cartilage of Santorini. A bundle of fibres answering to this de-iption I have met with in two cases out of nineteen in which they re sought for with special care. A similar bundle of fibres going he cartilage of Wrisberg has been described under the name of—

Thyreo-cuneiformis.—This I have not seen.

Thyreo-epiglotticus inferior (s. *major*) and *superior* (s. *minor*).—Two y thin laminae of muscular fibres arising from inner surface of roid cartilage, and ascending to the adjacent margin of the epi-tis, some blending with upper fibres of arytaeno-epiglottideus. rior frequently takes some fibres of origin from upper border of ro-arytenoideus. I have found one or both of these strata in about half of the cases in which they were carefully sought for before

decomposition had advanced too far, but always in an extremely atrophic state. Those fibres, which go directly to the margin of the epiglottis itself, have also been described under the name of *musculus epiglottidis* (*reflector* s. *depressor epiglottidis*.)

Thyreo-epiglotticus longus (C. Krause).—This band of muscular fibres I have found in two cases out of twenty-seven in which it was carefully sought for. Arising from inner surface of ala of thyroid cartilage, immediately above the incisura thyreoidea inferior lateralis, it passes upwards on the outer side of the thyreo-arytaenoideus, to be inserted with the fibres of the thyreo-ary-epiglotticus into the corresponding lateral margin of epiglottis.

Thyreoideus internus; sub-thyreoideus (Krause).—According to this author, a muscular bundle may be found in from 15 to 20 per cent. of all cases examined, passing from lower margin of ala of thyroid cartilage, near the middle line, backwards to the posterior attachment immediately above the root of the inferior cornu. I have found it twice in forty-three bodies.

Thyreoideus proprius (Krause).—The name has been applied by this author to a delicate layer of muscular fibres lying on the inner surface of the thyroid cartilage, and reaching from the incisura superior nearly to the inferior margin. In their descent they interlace with the other internal muscles. I have in a few cases found a small number of scattered vertical fibres in this situation, but never so arranged as to form a distinct layer.

Syndesmo-thyreoideus.—This name has been applied to a small muscle found in very rare instances (one per cent. according to Krause) passing from upper part of inner surface of thyroid cartilage to posterior thyro-hyoid ligament. I have met with it twice: in one subject it was symmetrically developed on both sides.

Kerato-arytaenoideus (*schildknorpelhorn-giessbeckenknorpels-muskel* of J. Gruber).—Arises from posterior border of inferior cornu of thyroid cartilage, and is inserted into the muscular process of the arytaenoid. I have found four examples.

Other anomalous laryngeal muscles have been described by many writers—such as the *hyo-epiglotticus* (Fabricius); *crico-epiglotticus* (Verheyen); *glosso-epiglotticus* (Eustachius); but I have never met with a specimen of any of them.

Digastric.—The only noteworthy anomaly of this muscle I have met with is a doubling of the anterior belly, the anomalous slip going to the median raphe of the mylo-hyoid muscles. Once I have found it symmetrical, the two supernumerary slips meeting in the mesial line, and in three other cases the anomaly existed on one side only.

Mento-hyoid (Macalister).—Of this muscle I have met with four examples. In all it lay superficial to the anterior belly of digastric, as it passed from front of body of hyoid bone to lower border of inferior maxilla. In one instance it was symmetrically developed.

Mylo-hyoideus.—The only remarkable variation I have seen in the attachments or relations of this muscle was a perforation of the posterior part by Wharton's duct, which came under my observation twice.

Genio-hyoideus.—I have in a good many cases found this muscle inseparably blended with the lower fibres of the genio-hyo-glossus.

Mylo-glossus (Rolfincius).—Of this muscle I have met with one example, passing in its usual direction from angle of jaw to side of base of tongue.

Stylo-glossus.—In five instances I have found this muscle with an accessory head from the stylo-maxillary ligament. Twice I have found it completely absent on one side.

Stylo-hyoideus.—In several instances I have seen the two parts into which this muscle was split by the tendon of the digastric separate from the origin to the insertion. I have seen the muscle inserted into the tendon of the digastric in one case. One instance of complete absence was noted.

Triticeo-glossus (Bochdalek, Macalister).—This anomalous bundle of muscular fibres I have succeeded in defining but five times in forty-four cases in which it was carefully sought for. This is much below the average of frequency which occurred in the experience of Bochdalek (8 in 22), and Macalister (1 in 6). Professor Krause makes the proportion of cases in which it occurs to vary from 17 to 36 per cent.

Azygos linguae; musculus longitudinalis linguae inferior medius (Bochdalek).—A small median bundle of longitudinal fibres found between the genio-hyo-glossi muscles in the posterior fourth of the tongue. I have been able to define it in five bodies out of forty-seven in which it was sought for.

Genio-glossus accessorius (Luschka).—A bundle of the lower fibres of the genio-hyo-glossus—from lowest part of genial tubercle to hyoid bone. I have succeeded in defining such a bundle as Luschka describes, separated from the other fibres of the genio-hyo-glossus about once in seven subjects.

Cephalo-pharyngeus (Sandifort).—Of this anomalous band of muscular fibres I have seen a good many examples:—Three arising from vaginal process of temporal bone; two from petrous portion of temporal bone (*petro-pharyngeus*) inside the inferior opening of the carotid canal; two from the spinous process of the sphenoid; one from the cartilaginous portion of Eustachian tube (*salpingo-pharyngeus*). In the majority of instances the fibres became united to those of the superior constrictor of the pharynx. In two examples they could be traced directly to the inferior constrictor.

Genio-pharyngeus (Winslow).—A slip closely connected along the anterior part of its course with the genio-hyo-glossus, and passing backwards to the side of the pharynx with the fibres of the superior constrictor. I have found several examples.

Syndesmo-pharyngeus.—This name has been given to a small fasciculus of muscular fibres passing from the posterior border of the thyro-hyoid ligament backwards to the median line (*linea alba*) of the pharynx. It bridges over the space intervening between the origins of the middle and inferior constrictors. I have found it twice in forty-seven subjects in which it was specially sought for.

Levator glandulae thyroideae lateralis.—Under this name Krause

mentions a few fibres of the inferior constrictor of the pharynx take origin from the side of the thyroid body. He says it is in about one per cent. of subjects examined. I have not fortunate as to meet with a specimen.

Azygos pharyngis (Meckel); *solitarius pharyngis* (Santo Under this name Meckel describes a small muscle, usually me single, rarely bilateral and symmetrical (Ketel, 1870), passing pharyngeal spine on the basilar process of the occipital bone dow for a variable distance along the median raphe of the phary which it is inserted. It is seldom more than half an inch in I have found it four times in eighty-seven subjects: once bila

Pharyngo-mastoideus (Ketel).—Arises from the anterior a aspect of the mastoid process, and passes inwards between and middle constrictors of pharynx to its insertion into the wall of the tube, blending with the fibres of these muscles. met with three examples.

Salpingo-pharyngeus (Sandifort).—A muscular fasciculus from Eustachian tube to side of pharynx behind the palato-pha I have met with one example.

Scalenus anticus.—I have occasionally seen this muscle vertebral origin more or less than that usually described. other remarkable peculiarity I have ever observed is, that instances I found the phrenic nerve piercing its fibres.

Scalenus medius.—The superior attachment of this muscle, a has correctly pointed out, is from the anterior, *not the posterior* t of transverse processes of the cervical vertebrae, as other an describe it. The usual number is six—all excepting the atla have found the number to vary from three, the smallest, to al In one case I found it attached below to the second rib onl very large proportion of subjects I found its vertebral attachme inseparable from the scalenus posticus.

Scalenus posticus.—In only two instances did I observe any anomaly of this muscle. One was complete absence. The ot attachment of lower end to third rib.

Scalenus minimus (Albinus).—The usual origin of this m from the anterior tubercles of transverse processes of fifth, si seventh cervical vertebrae, behind the attachment of anterior s to which it is often inseparably adherent. Its inferior extr connected to the second rib. Macalister makes the relative fr of its presence three times in seven subjects, and "oftener inseparably united to the other scalenes." Krause gives a pr of forty-two per cent. I have not been able to find it in so larg portion of cases: it was well defined five times in twen bodies.

Scalenus lateralis (Albinus); *musculus costo-transversalis.*—Thi arises from the transverse process of the seventh cervical verte passes downwards between the middle and posterior scalen little outside the latter (of which it would seem to be a portion) to its inferior attachment to second rib. I have

ur times: it was present in two of the twenty-three subjects in which the scalenes were specially dissected.

Scalenus accessorius.—Arises from the posterior tubercles of transverse processes of the cervical vertebrae from the fourth to the sixth (Macalister), from fourth to seventh (Krause), and is inserted into the st rib close to the scalenus medius, of which it seems to be a differentiated portion. It is separated from the latter muscle by part of the chial plexus.

Transversalis cervicis anticus longus colli accessorius (Luschka); *mus anticus proprius colli* (Krause).—This rare muscle arises from anterior tubercles of the transverse processes of the cervical tebrae, from the seventh to the fourth, and passing upwards is ched to the anterior surface of body of axis immediately below the erior articulating surface, and to the front of the base of the transverse process of the atlas. It is placed posterior to the rectus capitis ticus major. I have met but one example of this muscle.

Transversalis cervicis anticus (Retzius).—Arises from the oblique cesses of the cervical vertebrae, from the sixth to the fourth; being mately connected to the longus colli, and passing upwards is erted into the upper three cervical vertebrae. Of this rare muscle ave met with two specimens. One had the attachments described y Retzius; the second was attached by its upper extremity to the is alone, just below and outside the superior articular surface.

Transversalis cervicis medius (Krause).—Of this extremely rare scle I have never met with an example. Krause has found it ched to the front of the transverse processes of the cervical verte-, from the second to the sixth or seventh.

Transversalis cervicis posticus minor; trachelomastoideus minor; tra-mastoideus accessorius.—Arises from transverse processes of verte-, from the second dorsal to the fifth cervical, and ascending to its rtion is attached above to the transverse process of the atlas, and toid process of the temporal bone. I have noted one specimen.

Rhomboideus occipitalis (Murie, Mivart); *occipito-scapularis* Wood).—Arises from the internal third of the linea semicircularis dia ossis occipitis, above the attachment of the complexus, and is erted into the scapula, above the rhomboideus minor. I have met th three specimens of this muscle.

Levator claviculae (Wood); *cleido-cervicalis superior; trachelo-clavi-laris superior.*—The clavicular attachment of this muscle is either to middle third of the bone, or to its acromial extremity. The upper more variable in its points of fixation. It has been found attached to the transverse process of the atlas (*cleido-atlanticus*); to that of the xis (*cleido-epistrophicus*); to the oblique processes of the fourth and fth cervical vertebrae (*cleido-cervicalis inferior; scalenus anticus acces-sorius*); to the transverse process of the sixth alone (*cleido-cervicalis imus*). It has also been found attached to the transverse process of e third cervical vertebrae. The lower has, in some instances, been en to blend with the trapezius. I have met with two specimens of e cleido-cervicalis imus, and one of the cleido-epistrophicus. Another

mentions a few fibres of the inferior constrictor of the pharynx which take origin from the side of the thyroid body. He says it is present in about one per cent. of subjects examined. I have not been so fortunate as to meet with a specimen.

Azygos pharyngis (Meckel); *solitarius pharyngis* (Santorini).—Under this name Meckel describes a small muscle, usually mesial and single, rarely bilateral and symmetrical (Ketel, 1870), passing from the pharyngeal spine on the basilar process of the occipital bone downwards for a variable distance along the median raphe of the pharynx, into which it is inserted. It is seldom more than half an inch in length. I have found it four times in eighty-seven subjects: once bilateral.

Pharyngo-mastoideus (Ketel).—Arises from the anterior and inner aspect of the mastoid process, and passes inwards between superior and middle constrictors of pharynx to its insertion into the lateral wall of the tube, blending with the fibres of these muscles. I have met with three examples.

Salpingo-pharyngeus (Sandifort).—A muscular fasciculus passing from Eustachian tube to side of pharynx behind the palato-pharyngeus. I have met with one example.

Scalenus anticus.—I have occasionally seen this muscle taking a vertebral origin more or less than that usually described. The only other remarkable peculiarity I have ever observed is, that in two instances I found the phrenic nerve piercing its fibres.

Scalenus medius.—The superior attachment of this muscle, as Krause has correctly pointed out, is from the anterior, *not the posterior* tubercles of transverse processes of the cervical vertebrae, as other anatomists describe it. The usual number is six—all excepting the atlas—but I have found the number to vary from three, the smallest, to all, seven. In one case I found it attached below to the second rib only. In a very large proportion of subjects I found its vertebral attachment quite inseparable from the scalenus posticus.

Scalenus posticus.—In only two instances did I observe any notable anomaly of this muscle. One was complete absence. The other was attachment of lower end to third rib.

Scalenus minimus (Albinus).—The usual origin of this muscle is from the anterior tubercles of transverse processes of fifth, sixth, and seventh cervical vertebrae, behind the attachment of anterior scalenus, to which it is often inseparably adherent. Its inferior extremity is connected to the second rib. Macalister makes the relative frequency of its presence three times in seven subjects, and "oftener present inseparably united to the other scalenes." Krause gives a proportion of forty-two per cent. I have not been able to find it in so large a proportion of cases: it was well defined five times in twenty-three bodies.

Scalenus lateralis (Albinus); *musculus costo-transversalis.*—This muscle arises from the transverse process of the seventh cervical vertebra, and passes downwards between the middle and posterior scaleni and a little outside the latter (of which it would seem to be a detached portion) to its inferior attachment to second rib. I have found it

four times: it was present in two of the twenty-three subjects in which the scalenes were specially dissected.

Scalenus accessorius.—Arises from the posterior tubercles of transverse processes of the cervical vertebrae from the fourth to the sixth (Macalister), from fourth to seventh (Krause), and is inserted into the first rib close to the scalenus medius, of which it seems to be a differentiated portion. It is separated from the latter muscle by part of the brachial plexus.

Transversalis cervicis anticus longus colli accessorius (Luschka); *scalenus anticus proprius colli* (Krause).—This rare muscle arises from the anterior tubercles of the transverse processes of the cervical vertebrae, from the seventh to the fourth, and passing upwards is attached to the anterior surface of body of axis immediately below the superior articulating surface, and to the front of the base of the transverse process of the atlas. It is placed posterior to the rectus capitis anticus major. I have met but one example of this muscle.

Transversalis cervicis anticus (Retzius).—Arises from the oblique processes of the cervical vertebrae, from the sixth to the fourth; being intimately connected to the longus colli, and passing upwards is inserted into the upper three cervical vertebrae. Of this rare muscle I have met with two specimens. One had the attachments described by Retzius; the second was attached by its upper extremity to the axis alone, just below and outside the superior articular surface.

Transversalis cervicis medius (Krause).—Of this extremely rare muscle I have never met with an example. Krause has found it attached to the front of the transverse processes of the cervical vertebrae, from the second to the sixth or seventh.

Transversalis cervicis posticus minor; trachelomastoideus minor; trachelomastoideus accessorius.—Arises from transverse processes of vertebrae, from the second dorsal to the fifth cervical, and ascending to its insertion is attached above to the transverse process of the atlas, and mastoid process of the temporal bone. I have noted one specimen.

Rhomboideus occipitalis (Murie, Mivart); *occipito-scapularis* (Wood).—Arises from the internal third of the linea semicircularis media ossis occipitis, above the attachment of the complexus, and is inserted into the scapula, above the rhomboideus minor. I have met with three specimens of this muscle.

Levator claviculae (Wood); *cleido-cervicalis superior; trachelo-clavicularis superior.*—The clavicular attachment of this muscle is either to the middle third of the bone, or to its acromial extremity. The upper is more variable in its points of fixation. It has been found attached to the transverse process of the atlas (*cleido-atlanticus*); to that of the axis (*cleido-epistrophicus*); to the oblique processes of the fourth and fifth cervical vertebrae (*cleido-cervicalis inferior; scalenus anticus accessorius*); to the transverse process of the sixth alone (*cleido-cervicalis imus*). It has also been found attached to the transverse process of the third cervical vertebrae. The lower has, in some instances, been seen to blend with the trapezius. I have met with two specimens of the cleido-cervicalis imus, and one of the cleido-epistrophicus. Another

specimen I have found attached above to the oblique processes of the third, fourth, and fifth cervical vertebrae, and inserted below into the middle third of upper border of clavicle.

Rhombo-atloideus (Macalister, 1866); *splenius accessorius* (Krause); *adjutor splenii* v. *m. singularis splenius accessorius* (Walther).—This muscle passes from the spinous processes of the last cervical or first dorsal vertebra—where it arises beneath the rhomboideus minor—to the transverse process of the atlas. It has been found attached to the sixth and seventh cervical spines, or to the seventh alone, or to the first and second dorsal spines, or to the second and third. I have found three examples in which the muscle arose from the last cervical and first dorsal spines, and one in which it arose from the three upper dorsal. In two cases the origin was from the two upper dorsal vertebrae. Mr. Wood found it three times in thirty-six subjects, and Krause gives eight as its percentage of frequency. I have found it six times in seventy-five subjects.

Atlanto-mastoideus.—Arises from transverse process of atlas, and is inserted into the posterior border of the mastoid process of the temporal bone. Krause makes its relative frequency to be thirty per cent. of subjects examined; this is much greater than what has occurred in my experience, as I have found it but four times in thirty-three subjects which were carefully examined for it.

Rectus capitis anticus major, . . . *minor.*—Doubling of these muscles I have pretty often observed, but have kept no account of the relative frequency.

Rectus capitis lateralis accessorius (Winslow).—This muscle, a doubling of the normal rectus capitis lateralis, I have found three times in thirty-three subjects in which it was specially sought for.

Pectoralis major.—The three parts of this muscle I have found completely distinct in four instances. The clavicular, sternal, and costal portions could easily be differentiated even down to their very insertion into the humerus. In two cases I have seen an accessory slip to the short head of the biceps taking origin from the lower border of the tendon. In one case the tendon divided into two parts, between which passed the long tendon of the biceps, one lamina going to either lip of the bicipital groove.

Pectoralis major accessorius.—Arises from the costal cartilages from the first or second to the sixth or seventh, and passes outwards beneath the deep fibres of the pectoralis major to join the tendon of insertion. It is but a complete differentiation of the costal portion of the pectoralis major.

Chondro-epitrochlearis.—Of this muscle I have met with four specimens. The attachments were the same in all cases. The origin was from the sixth costal cartilage, and the fibres were placed in close apposition with the lower fibres of the pectoralis major. The insertion was into the brachial aponeurosis at the lower fourth of the arm on its inner aspect—one sending a slight tendinous slip down to the epitrochlea. So that the muscle in all these cases better deserved the name of *chondro-fascialis.*

Pectoralis minor.—In five cases I have seen the tendon of this muscle send a strong slip over the coracoid process to pierce the coraco-acromial ligament, and blend with the capsule of the shoulder-joint. In one instance the whole tendon wound over the coracoid process, and divided into two strong bands; one went to the margin of the glenoid cavity, the second to the greater tuberosity of the humerus.

Pectoralis minimus (Gruber).—Arises from anterior surface of manubrium sterni, rhomboid ligament, and cartilage of first rib, and passes outwards in front of the costo-coracoid membrane to be inserted into the inner border of the coracoid process of the scapula. It sometimes arises from the cartilage of the first rib alone, and such was the origin of the muscle in the two examples which I have met with.

Pectoralis quartus.—Arises from the fascia over the lower part of the serratus magnus, and occasionally from the adjacent portions of one or more ribs, and is inserted into the lower border of the tendon of the great pectoral, or into the oschelbogue of Lauger.

Subclavius.—This muscle I have found completely absent in two instances. In both the deficiency was on the left side.

Supra clavicularis proprius, v. *tensor fasciae colli* (Gruber); *anomalus claviculae.*—Of this muscle I have met with two examples, one of which has been already recorded (vide *Journal of Anatomy and Physiology*, xv. 139).

The second specimen (observed during the last winter session) had similar attachments, but was much smaller.

Acromio-clavicularis, v. *praeclavicularis lateralis* (Gruber).—Consists of a few muscular fibres passing from the outer third of the clavicle to the tip of the acromion. I have, on one occasion, seen a small band of fibres in situation so very delicate as hardly to deserve the dignity of a special name. It lies superficial to the upper fibres of the deltoid.

Omo-clavicularis (*coraco-clavicularis,* v. *coraco-clavicularis posticus,* Calori, Gruber).—This muscle arises from the outer end of the clavicle, less frequently from the inner end, sometimes also from the manubrium sterni, and passes outwards to be inserted into the coracoid process of the scapula. The insertion is sometimes into the upper border of this bone. A similar muscular band has been described by Mr. Wood under the name of—

Scapulo-clavicularis.—This I have never succeeded in finding, although I have sought for it in more than a hundred and twenty subjects.

Sterno-clavicularis; sterno-clavicularis anticus; prae-clavicularis medius (described and named by Gruber).—Arises from manubrium sterni, anterior sterno-clavicular ligament, and cartilage of first rib—sometimes from only one of these points of attachment—and passes outwards in front of the subclavius to be inserted into the middle third of the clavicle. It has been found inserted into the coracoid process of the scapula, when it received the name of—

Coraco-clavicularis anticus, v. *singularis.*—Of the latter insertion

I have met with one case. I have never seen the more frequent form of this anomaly.

Supra-clavicularis; sterno-clavicularis (Hyrtl); *sterno-clavicularis superior; sterno-omoideus.*—Arises from anterior surface of manubrium sterni, and is inserted into the front of the clavicle at a variable distance from its outer end. When symmetrically developed, the two muscles often meet in the middle line, forming a

Musculus interclavicularis.—Of this latter form of the anomaly I have seen two examples. I have observed but one specimen of unilateral development.

Retro-clavicularis (Weber); *sterno-clavicularis posticus.*—Arises from posterior surface of manubrium sterni, and is inserted into the inner end of the clavicle, on its posterior surface. I have seen one specimen, but it had, as in the one observed by Lawson Tait, a second head from the posterior sterno-clavicular ligament.

Infra-clavicularis (Bardeleben).—Arises from front of clavicle, and is inserted into the fascia in front of the pectoralis major. I have met with one example: it arose fleshy from the clavicle for about an inch of the middle of its anterior border and formed a tendinous expansion, which, passing downwards and outwards, and intersecting, at a very acute angle, the line of direction of the clavicular fibres of the pectoralis major, bended with the fascia, in front of the latter muscle, after a course—including the length of the fleshy fibres—of about four inches. So far as I know, this is the only example published, except that of Bardeleben.

Subclavius posticus; scapulo-costalis; sterno-scapularis.—Arises from the first rib, and is inserted into the root of the coracoid process of the scapula, or into the ligament of the notch. I have seen but one example occurring in a large number of subjects, having examined this region carefully for anomalies, in over a hundred. Krause says the frequency of its occurrence averages seven per cent., and according to Professor Macalister it is met with once in fifteen subjects.

Supra-costalis superficialis (vel *anterior*).—A bundle of muscular fibres passing from one of the upper ribs (generally the first) to another rib at a variable distance below. It lies beneath the pectoralis major and minor.

Supra-costalis profundus.—This bundle of fibres, when present, lies beneath the serratus anticus magnus. I have met with a good many specimens of both *superficialis* and *profundus*, but did not feel sufficiently interested in the anomaly to keep any record of them.

Transversus colli (Luschka); *costo-fascialis cervicalis* (Macalister).—This muscle arises from the first rib, and passing obliquely inwards behind the clavicle, and between the sterno-hyoid and sterno-thyroid muscles, is inserted into the deep fascia at the root of the neck (septum thoracico-cervicale). Professor Krause suggests that it may be regarded as an upper differentiated digitation of the triangularis sterni muscle.

Tensor semivaginae articulationis humero-scapularis (Gruber).—This

rare muscle arises from the front of the manubrium sterni and cartilage of first rib, and passes outward between pectoralis major and minor, to be inserted into the front of the capsule of the shoulder-joint. I have found on one occasion a bundle of fibres arising from the cartilage of the first rib at its junction with the bone, and passing outwards between the greater and lesser pectoral muscles, to be inserted into the anterior aspect of the shoulder capsule.

To the anomalies of the muscles of the back, of the diaphragm, and of the flat muscles of the abdomen I have not given special attention, although some remarkable deviations from the typical arrangement have been met with.

Basio-deltoideus; fasciculus infraspinata deltoideus (Gruber).—This bundle of fibres is accessory to the normal deltoid muscle, and corresponds to the abductor brachii inferior of the lower mammals (W. Krause, *Anatomie des Kaninchens*, 1868). It arises from the vertebral border of the scapula at a variable level, sometimes as low down as the inferior angle of the bone, and passes outwards to join the lower fibres of the deltoid. Of this form of the accessory muscle I have met with two examples. Other accessory bundles have been described. One from the axillary border of the scapula has been named *costo-deltoideus:* a separate slip from the acromial end of the clavicle has been named *acromio-clavicularis lateralis.* Still rarer specimens are those which have been described under the names of *tensor fasciae deltoideae a fascia infraspinata* and *tensor fasciae deltoideae a margine axillari scapulae,* respectively. I have never met with any of these latter forms.

Infra-spinatus.—This muscle I have twice seen to receive an accessory slip from the deltoid. I have seen a good many specimens (over five in number) in which it was quite inseparable from the teres minor. The upper fibres of the muscle are sometimes quite separate from the remainder, forming what has been described as the *infra-spinatus minor.* Of this variety I have seen one well-defined example.

Teres minor.—Fusion with the infra-spinatus has been already mentioned. Complete absence of the muscle I have once observed.

Teres minimus.—Under this name has been described a bundle of fibres parallel to and in close contact with the lower edge of the teres minor. I have seen one example occurring on both sides of a male subject of great muscular development.

Subscapularis minor; subglenoidalis; infra-spinatus secundus; subscapulo-humeralis; subscapulo-capsularis.—Under this name has been described an upper detached portion of the subscapularis muscle. Arising from the upper part of the axillary border of the scapula, sometimes from the tuberculum infra-glenoidale, where it adheres to the long head of the triceps, it passes outwards to be inserted either with the normal subscapular tendon into the lesser tuberosity of the humerus, or what much more frequently happens, into the front of the capsule of the shoulder-joint (*subscapulo-capsularis,* Gruber, Macalister). According to Professor W. Krause, the frequency of its occurrence varies from five to thirty-three per cent. I have found it four

(Struthers).—This slip arises from the inner side of the biceps, and passing obliquely downwards and inwards, crosses in front of the brachial artery, and is inserted into the fascia over the pronator radii teres. Of this anomaly I have met with four examples.

Brachialis anticus.—This muscle I have found in three instances completely cleft from origin to insertion—but its attachments were in other respects quite normal. Continuity of its outer fibres with those of the supinator longus, as described by Wood and Macalister, I have seen in one case, giving rise to the formation of a tunnel through which passed the musculo-spiral nerve with the accompanying branch of the superior profunda artery. An accessory head from coraco-brachialis I have [illegible]es. Of its inferior attachments I have seen the foll[illegible]ending a slip to the tendon of the pronator radii ter[illegible]ved twice; a slip to the supinator longus below the leve[illegible]joint—this I have seen occurring on both sides in one s[illegible]o the flexor sublimis digitorum—of which I found one [illegible]ery muscular subject (male).

Brachialis internus [illegible]s muscle, which is but a detached slip of the brachialis ant[illegible]net with three specimens in forty-nine subjects. In two [illegible]on the radial side of the muscle, and was inserted into [illegible] the inferior part of the bicipital tuberosity; in one it la[illegible] side of the muscle, and was inserted separately a little [illegible]vel of coronoid process.

Triceps brachii.—I ha[illegible] noteworthy variations from the typical attachments of this muscle. Apparent direct continuity of the triceps and anconeus I have several times observed. A distinct slip from the tendon of the subscapularis at its attachment of the lesser tuberosity I have once seen. In two cases of seventeen subjects (which were specially examined for it) I found a bursa between the internal part of the triceps and the ulnar nerve as it lies behind the epitrochlea. (*Bursa mucosa retro-epitrochlearis* of Gruber.) I have noted four examples of the accessory slip from the lower border of the tendon of the latissimus dorsi, described by Professor Halbertsma under the name of *anconeus quintus*.

Another muscular slip has been described under the name of *anconeus quintus* (vel *minimus*); *epitrochleo-anconeus* (of Gruber); *anconeus epitrochlearis* (Wood).—This muscle arises from the back of the inner condyle of the humerus, and is inserted into the olecranon process of the ulna. Its bulk and extent of attachment are very various; according to most authorities it would seem to be present in about a fourth of the subjects examined.

Subanconeus.—The only peculiarity I have met with in this muscle is the frequency of its absence. Indeed I have but seldom been able to define its existence as a separate muscle, and have been led to wonder why it is described in all the hand-books as a separate muscle. Under the head of the anomalies of the triceps extensor cubiti I would also include the slip described by Gruber under the name of *levator tendinis latissimi dorsi*. It arises from the coracoid process.

adjacent part of the capsule of the shoulder-joint, and is inserted into the upper margin of the tendon of the latissimus dorsi.

Supinator radii longus accessorius; brachio-radialis accessorius; brachio-radialis brevis (vel minor).—Arises with the supinator longus and is inserted a little below the level of the tuberosity of the radius. I have seen one specimen: it is present, according to Krause, in about one per cent. of the bodies examined. The insertion of supinator radii longus I have found double in one case, the upper tendon being attached to the outer surface of the radius about three inches above the level of the styloid process. The radial head passed between it and the lower tendon, which had the normal insertion of supinator longus.

Extensor carpi radialis accessorius (Wood).—Arises from the outer condyle of the humerus below the attachment of the extensor carpi radialis longior, and travels with the latter muscle—passing through the same groove in the posterior annular ligament of the wrist, and goes thence to its insertion into the base of the first metacarpal bone. I have found it once in a muscular subject. The inferior attachment of this muscle may be into the back of the scaphoid bone, or base of first metacarpal, or into both, as it was in my case; or into outer edge of abductor pollicis, or of outer head of flexor brevis pollicis.

Pronator radii teres.—The two heads of this muscle I have found separate through their whole length down to the radial insertion. It occurred in three instances; in one case on both sides. Twice I have seen a third head arising from the ulna about two inches below the level of the coronoid process.

Flexor carpi radialis.—This muscle I have seen in four instances taking an accessory slip from the inner margin of the coronoid process of the ulna. In two of them the median nerve passed between the heads. With regard to its insertion, I agree with Professor W. Krause in making the normal one to be into both second and third metacarpal bones. This I found to be the case in nineteen out of thirty-four specimens of the muscle, in which the attachments were made out with care. In one of these cases the insertion was into the trapezium; in another into trapezium and second metacarpal; in another into third and fourth metacarpal.

Flexor carpi radialis brevis (v. *profundus*); *radio-carpus* (Fano); *radialis internus brevis* v. *minor*, v. *profundus* (Gruber).—One well-developed specimen of this muscle was found among the thirty-four subjects whose fore-arms I specially examined for muscular anomalies. The origin was from the radius outside the flexor pollicis longus, reaching from the lower end of the oblique line down to about the junction of middle with lower third of outer edge of pronator quadratus. Its tendon passed through a separate canal in the anterior annular ligament close to that for the flexor carpi radialis, and divided into two slips, which went to be inserted into the front of the bases of the second and third metacarpal bones. I have met since with two other specimens of this muscle, similar in origin, but neither nearly so well developed. The insertion varied in each case: one was inserted into the trapezium (the true *radio carpus* of Fano); the other was

inserted by two slips into trapezium and base of second metacarpal bone (*radio-carpo-metacarpalis*).

Palmaris longus.—This, which enjoys the distinction of being the most variable muscle in the body, I found absent in four of thirty-four subjects. In one case the deficiency was symmetrical; in the other three unilateral—two on the left side, one on the right. In the case of bilateral absence, the subject was a female, the others were males. A second head from the coronoid process was present in two instances. There was one example in which the fleshy belly was two and a-half inches in length. In one case the tendon was inserted directly into the outer margin of the abductor pollicis, just below its origin.

I have since met with a specimen in which the insertion was into the tuberosity of the scaphoid bone. Also an example of doubling of the muscle, both heads coming from the internal condyle, but the second head lying beneath the other, and not coming from the common tendon. The deep head has received the name of *palmaris longus accessorius* (Krause).

Flexor digitorum sublimis.—Absence of the tendon for the little finger I have observed in three instances. The index flexor I have, in two cases, found quite distinct from the rest of the muscle, from its origin to its insertion.

Flexor carpi ulnaris.—This muscle I have once found wholly inserted into the anterior annular ligament. The palmaris longus was absent.

Flexor carpi ulnaris brevis.—Of this muscle I have met with one specimen. The origin was from the ulna, inside the upper end of the flexor digitorum sublimis, for about two inches in length. It passed through a separate canal in the anterior annular ligament, and was inserted into the base of the fourth metacarpal bone.

Flexor digitorum profundus.—The only notable variety of this muscle I have seen was a complete isolation of the index portion along its whole length. This occurred twice in thirty-four subjects examined; and I have seen some other examples, of which I took no note.

Flexor digitorum profundus accessorius; musculus accessorius ad digitorum profundum (Gantzner).—One example of this muscle I have seen arising from the inner side of the coronoid process; it formed two tendons which went to the middle and little fingers. The tendons pierced the corresponding ones of the sublimis, and were accompanied by very small tendinous bands from the normal flexor profundus.

Flexor pollicis longus.—This muscle received, in two cases of the thirty-four subjects specially examined, an accessory head from the internal condyle. The coronoid head, which in some form was present in eighteen cases, arose separately in nine; in common with the deep head of pronator radii teres, in three; closely adherent to the coronoid head of flexor sublimis digitorum, in four; and by a slip common to all three in the remaining two. An accessory slip, coming directly from the fleshy fibres of the flexor sublimis digitorum, was present in one case; and such a muscular bundle is mentioned by Krause under the name of *fasciculus exilis*.

Pronator radii quadratus.—Complete separation into two parts

occurred twice in thirty-four subjects, and I have seen several other examples. The bilaminar form described by Meckel and Macalister occurred once. Once the muscle almost formed a triangle, the truncated apex of which was formed by the radial end.

Cubito-carpeus.—This rare muscle arises from lower end of ulna, where it is in close contact with the pronator quadratus, forming, in fact, a detached portion of the latter; and it passes inwards to be inserted into the tuberosity of the scaphoid bone and base of the first metacarpal. It nearly corresponds to the *ulno-carpalis singularis anterior* of Gruber; but the latter is large at its ulnar attachment as the normal pronator, and is wholly inserted into the carpus.

Tensor ligamenti annularis (v. *orbicularis*) *dorsalis* (v. *posterior*).—Arising from the ulna behind the lesser sigmoid cavity, it is inserted into the posterior surface of the orbicular ligament of the radius. I found it as a distinct slip six times in thirty-four subjects. According to Macalister, its proportional frequency as a separate muscle is twenty-five per cent. of subjects examined; according to Gruber it has been found in seventy-four per cent. of fore-arms.

Tensor ligamenti annularis (v. *orbicularis*) *volaris* (v. *anterior*).—Arises from the coronoid process of the ulna, and is inserted into the anterior surface of the orbicular ligament of the radius. It is much less frequently seen than the other: it occurred in my cases twice in thirty-four subjects: according to Krause, the average frequency of its occurrence is seven per cent.

Supinator radii brevis accessorius.—Is a small slip from the brachialis anticus, going to the tubercle of the radius. I have seen two specimens.

Extensor carpi radialis longior; brevior.—These muscles I have found completely inseparable five times in thirty-four bodies. In one of the cases three tendons were given off—one to the second metacarpal bone, two to the third. In another instance a normal longior sent an accessory tendon to accompany that of brevior. Brevior had a double insertion in two of the fore-arms into second and third metacarpal bones.

Extensor communis digitorum.—Absence of the little finger tendon occurred in three of the subjects already referred to. Doubling of one or more of the tendons occurred in a large proportion of cases, but I made no note of the exact number.

Extensor minimi digiti.—This was completely absent in one instance. In two other cases there was a double tendon: in one of these the two slips were inserted together; in the other the second tendon went to the metacarpal bone of the ring finger. In one case the muscle was double, the second part forming the *extensor minimi digiti accessorius* (Krause).

Extensor brevis digitorum manus.—A rudimentary muscle, which is found in various forms of development on the back of the hand. The proportion of cases in which it occurs is, according to Krause, from three to seven per cent. It arises most frequently from the posterior annular ligament (Krause); sometimes from the end of the radius (Albinus, Humphry); from the bases of one or more of the metacarpal

bones (Wood, Macalister, &c.). I have seen but one specimen; it arose from the bases of the second and third metacarpal bones, and took some fibres from the adjacent part of the posterior annular ligament, and gave off two tendons which went to the index and middle digits—each joining with the corresponding tendon of the long extensor.

Extensor ossis metacarpi pollicis.—The tendinous end of this muscle presents very frequent variations. I have seen the tendon double; the second slip going in one case to the trapezium; in two instances to the abductor pollicis. A triple tendon occurred once: one had the normal attachment, the other two slips went to the trapezium, and to outer edge of abductor pollicis respectively. A quintuple tendon existed in one case: two of the slips went to the normal insertion, two to the trapezium, and one to become fused with the extensor primi internodii pollicis.

Extensor primi internodii pollicis.—This muscle was completely absent in one case; and in two others sent an accessory tendinous slip to the extensor secundi.

Of the muscles of the thenar eminence few notable variations were observed.

Abductor pollicis brevis alter; abductor pollicis internus.—Of this accessory bundle of muscular fibres—arising with the normal abductor and on its inner side—I have seen two examples.

Adductor pollicis.—In a large number of cases (of which, indeed, I kept no accurate record) the radial artery divided the muscle into two parts, as has been specially described by Bischoff, who has given the two divisions the names of *adductor pollicis obliquus,* and *adductor pollicis transversus* respectively.

Abductor minimi digiti.—This muscle I have found arising by two completely separate heads; one from the pisiform bone, the second from the anterior annular ligament.

Lumbricales.—The first was absent twice in thirty-four subjects. Both first and second were absent in another.

Psoas parvus.—A remarkable specimen of this muscle was met with last session. It had the usual origin; but the insertion was into the side of the cartilage between third and fourth lumbar vertebrae.

Iliacus minor; ilio-capsularis.—Analogous to the subscapularis minor in upper extremity. Arises from anterior inferior spine and ilio-femoral ligament, and is inserted, a little above the iliacus tendon into the spiral line.

Tensor vaginae femoris.—In one case the origin of the muscle was three-quarters of an inch distant from the anterior superior spine of the ilium. The only other variation I have observed is the great difference in the length of its fibres in different subjects.

Sartorius.—I once found inserted into the inside of the capsule of the knee-joint.

Adductor minimus (Henle); *adductor quartus* (Diemerbroeck).—This muscle is merely the upper and outer part of adductor magnus; I consider it worthy of separate mention because I have found it quite

distinct muscle in the vast majority of cases I have examined. This has also been the experience of Professor Macalister.

Gluteus quartus; invertor femoris; scansorius.—This muscle is formed by a differentiated portion of the anterior part of the glutaeus minimus. When present its origin reaches as high as the anterior superior spine of the ilium. I have found it very distinct in three cases.

Gemellus superior.—This muscle I have found frequently absent. The inferior muscle I have never missed.

Quadratus femoris was found completely absent in two instances. One of these has been already published.

Biceps flexor cruris.—A third head to this muscle from the upper part of the linea aspera I have once seen. Absence of the short head was noted in two instances.

Gastrocnemius.—A third head of this muscle from the popliteal surface of the femur I have twice seen (*gastrocnemius tertius*, Krause). Accessory fibres of outer head arising from the external lateral ligament of the knee-joint I have found present in five instances.

Popliteus.—I have once found an accessory slip to this muscle arising above the normal popliteus from the external condyle of the femur.

Tensor capsuli tibio-tarsalis.—A very well developed specimen of this muscle I have once met with, arising from the outer surface of the tibia for the lower third, below and outside the tibialis anticus, and going to be inserted into the anterior annular ligament of the ankle-joint.

Peroneus quartus (Otto); *sextus* (Macalister); *p. accessorius.*—Of this muscle I have found one well-developed specimen (already published). It arose from the lower part of outer surface of fibula, where its fibres were found continuous with the lower part of the peroneus brevis. The insertion was into the outer surface of the os calcis, just behind the peroneal tubercle.

Peroneo-tibialis.—Arises from inner side of fibula just below the head, and is inserted into the oblique line of the tibia. Krause says it is present in eighteen per cent. of the subjects examined, and considers it analogous to the ulnar head of pronator radii teres. I have found it four times in forty-nine subjects in which it was specially looked for.

Pronator pedis; peroneo-calcaneus internus.—Arises from the fibula beneath and outside the origin of the flexor longus pollicis, and is inserted into the inside of the os calcis. It was considered by Meckel to be the analogue of the pronator quadratus in the upper extremity. I have seen but one example. The insertion was into the sustentaculum tali.

Besides the anomalies enumerated in the preceding pages, I have in my possession scattered notes of a considerable number, still unclassified, chiefly of the muscles of the lower extremity, which time has not permitted me to tabulate, but of which I shall take the earliest opportunity that time may afford to publish a complete list.

LXIV.—Preliminary Note on the Plane Representation of Certain Problems in the Dynamics of a Rigid Body. By Robert S. Ball, LL.D., F.R.S.

[Read, April 11, 1881.]

The present Paper applies to the case where the rigid body has freedom of the third order, and while the body remains in or near to its original position. Three co-ordinates will then specify any position which the body can attain. Two independent co-ordinates will specify the screw about which the body is twisting. The screws in the system can be most conveniently designated by three homogeneous co-ordinates of which only the ratios are concerned. The representation of a screw is therefore analogous to the representation of a point in a plane by trilinear co-ordinates. The object of this Paper is to develop this analogy. The reader is presumed to be acquainted with the elements of the *Theory of Screws.*

Let θ_1, θ_2, θ_3, be the co-ordinates of a screw θ, referred for convenience to the three principal screws of the *three-system*, which defines the freedom of the body (see *Theory of Screws*, p. 116). We can also denote the position of a point in a plane by the three co-ordinates θ_1, θ_2, θ_3, and hence we are led to the result that

To each screw of a three-system corresponds one point in the plane.

The converse of this is also *generally* true. It would be universally true but for one conic, and four points thereon, of a very remarkable character. To each of these points corresponds a whole plane of screws in the three-system, while the remaining points on the conic have no screws corresponding to them.

Two screws determine a cylindroid, and the co-ordinates of any third screw on the cylindroid are linear functions of the co-ordinates of the two given screws; and hence

To each cylindroid of screws belonging to the three-system corresponds a straight line in the plane.

It is well known that any two cylindroids of a three-system have one common screw. This theorem becomes sufficiently obvious when the cylindroids are represented by right lines, the common screw of course corresponding to their intersection.

If p_α, p_β, p_γ, be the pitches of the three principal screws of the system (*Theory of Screws*, p. 121), then the pitch p_θ of any other screw θ is given by the equation

$$p_\alpha\theta_1^2 + p_\beta\theta_2^2 + p_\gamma\theta_3^2 - p_\theta(\theta_1^2 + \theta_2^2 + \theta_3^2) = 0.$$

If we regard p_θ as given, then this equation corresponds to a conic section in the plane. To each pitch p_θ will correspond a different

conic. All the conics will form a family of the type $S + kS' = 0$, and they intersect in the same four points. These points are defined by the equations

$$p_\alpha\theta_1^2 + p_\beta\theta_2^2 + p_\gamma\theta_3^2 = 0,$$
$$\theta_1^2 + \theta_2^2 + \theta_3^2 = 0.$$

The first of these equations denotes the conic which corresponds to the screws of zero pitch. The second of the equations denotes the locus of the screws of infinite pitch. It is the exceptional conic just referred to. The four points common to their conics are of indeterminate pitch; they are indeed the exceptional points, and of course they are imaginary.

It has been shown (*Theory of Screws*, p. 121) that the locus of the screws of pitch p_θ in the three-system is the quadric

$$(p_\alpha - p_\theta)x^2 + (p_\beta - p_\theta)y^2 + (p_\gamma - p_\theta)z^2 + (p_\alpha - p_\theta)(p_\beta - p_\theta)(p_\gamma - p_\theta) = 0.$$

This is the real part of the locus, but the complete locus contains an imaginary portion also. This fact is at once exhibited by the plane representation. A straight line in the plane represents a cylindroid, *i. e.* a surface of the third degree. It hence followed that a conic in the plane should correspond to a surface of the sixth degree. We thus learn that the real locus of the screws of any given pitch must be *a surface of the sixth degree*, and that consequently the quadric with which we were already acquainted requires to be multiplied by a factor of the fourth degree.

It can be shown that this factor is the product of the four planes, produced by giving variety of sign to the coefficients in

$$\sqrt{p_\beta - p_\gamma}\,x + \sqrt{p_\gamma - p_\alpha}\,y + \sqrt{p_\alpha - p_\beta}\,z + \sqrt{p_\beta - p_\gamma}\sqrt{p_\gamma - p_\alpha}\sqrt{p_\alpha - p_\beta} = 0.$$

In general, if x, y, z be the co-ordinates of a point on a screw belonging to the system, and if θ_1, θ_2, θ_3 be its co-ordinates, then we have

$$x(\theta_2^2 + \theta_3^2) - y\,\theta_1\theta_2 - z\,\theta_1\theta_3 + (p_\beta - p_\gamma)\theta_2\theta_3 = 0,$$
$$y(\theta_3^2 + \theta_1^2) - z\,\theta_2\theta_3 - x\,\theta_2\theta_1 + (p_\gamma - p_\alpha)\theta_3\theta_1 = 0,$$
$$z(\theta_1^2 + \theta_2^2) - x\,\theta_3\theta_1 - y\,\theta_3\theta_2 + (p_\alpha - p_\beta)\theta_1\theta_2 = 0.$$

In the present case

$$\theta_1^2 : \theta_2^2 : \theta_3^2 :: p_\beta - p_\gamma : p_\gamma - p_\alpha : p_\alpha - p_\beta,$$

whence each of these equations reduces to

$$\sqrt{p_\beta - p_\gamma}\,x + \sqrt{p_\gamma - p_\alpha}\,y + \sqrt{p_\alpha - p_\beta}\,z$$
$$+ \sqrt{p_\beta - p_\gamma}\sqrt{p_\gamma - p_\alpha}\sqrt{p_\alpha - p_\beta} = 0.$$

Through each point in this plane a line can be drawn, whose direction cosines are proportional to

$$\sqrt{p_\beta - p_\gamma},\ \sqrt{p_\gamma - p_\alpha},\ \sqrt{p_\alpha - p_\beta},$$

It is remarkable that this line, besides lying in the plane, is also normal thereto, and with *any pitch whatever* this line will be a screw of the system.

Each of these planes of screws will correspond to one of the four remarkable points through which all the pitch conics pass. The plane representation of the screws in the three-system is thus seen to be more complete than the family of pitch quadrics which, until supplemented by the four imaginary planes, is not an adequate locus for all the screws of given pitch.

It will be convenient for our immediate purpose to designate the conics by the pitches to which they correspond. Thus we have the *zero-pitch conic*, the *infinite-pitch conic*, and their points of intersection we may speak of as the *fundamental points.*

Let θ and ϕ be two screws of the system, if they are reciprocal then (*Screws*, p. 35)

$$p_\alpha \theta_1 \phi_1 + p_\beta \theta_2 \phi_2 + p_\gamma \theta_3 \phi_3 = 0,$$

whence we deduce the result that

If two screws are reciprocal, then their corresponding points are conjugate with respect to the zero-pitch conic.

If the two screws were at right angles, then we would have the following relation between their co-ordinates:

$$\theta_1 \phi_1 + \theta_2 \phi_2 + \theta_3 \phi_3 = 0;$$

whence we find

[illegible] screws are reciprocal, then their corresponding points are conju[illegible] respect to the infinite-pitch conic.

It will also be easy to show that

The angle between two screws is proportional to the logarithm of the [illegible] ratio in which the line joining their corresponding points [illegible] by the infinite-pitch conic.[1]

[1] [illegible] the infinite-pitch conic as the *absolute*, then the angle between [illegible] else than the "distance" in the non-Euclidian sense between [illegible] points.

The vertices of the self-conjugate triangle that can be constructed with respect to the two conics correspond to screws mutually reciprocal and rectangular, whence

The principal screws of the three-system correspond to the vertices of the triangle which is self-conjugate with regard to the zero-pitch, and the infinite-pitch conic.

For the determination of a three-system nine data are required—for example, nine data will give the pitch quadric, and when that is known the rest of the system is determined. An equal number of data is required for the plane representation. Five of these may conveniently specify the zero-pitch conic, while the specification of the four fundamental points thereon will absorb the remainder.

The conic and four points being known, the self-conjugate triangle is determined; the equation of the conic referred to that triangle is therefore known, and thus the pitches p_α, p_β, p_γ of the three principal screws are determined. It remains to be shown how the pitch of the screw corresponding to any other point in the plane is to be ascertained.

It is not difficult to prove the following theorem:—

Measure off distances p_α, p_β, p_γ, p_θ on a straight line from an arbitrary point, then the anharmonic ratio of the four points thus obtained is equal to the anharmonic ratio which the point corresponding to θ subtends at the four fundamental points.

We are now able to construct the infinite-pitch, or any other pitch conic, from the primitive data, as the problem is merely to draw a conic through four points so that the anharmonic ratio subtended at those four points by a variable point shall be given.

Each screw of a three-system has one screw of the reciprocal system parallel to it, with a pitch of changed sign. If we take a plane representation and change the signs of all the pitches, then the new arrangement gives the screws of the reciprocal system parallel to all those of the old.

Two conics can be described through the four fundamental points to touch any given straight line; the two points of contact will indicate the two principal screws on the cylindroid corresponding to the straight line. The other pitch conics will cut the line in points which form an involution, each pair corresponding to the two screws of the same pitch on the cylindroid.

The polar of a point with regard to the zero-pitch conics corresponds to the cylindroid which is the locus of screws in the three-system reciprocal to a given screw.

On each cylindroid one screw ϕ reciprocal to a given screw θ can be found. It is only necessary to take the polar of θ with regard to the zero-pitch conic, and the point in which it intersects the line corresponding to the cylindroid gives the required screw.

By the aid of the plane representation we are enabled to solve many

problems in the dynamics of a rigid body which has freedom of the third order.

Let an impulsive wrench act upon a quiescent rigid body; it is required to determine the instantaneous screw about which the body will commence to twist.

It can be easily shown (*Screws*, p. 59) that the impulsive wrench, *wherever situated*, can always be adequately represented by an impulsive wrench on a screw of the three-system. The problem is therefore reduced to the determination of the point corresponding to the instantaneous screw, where that corresponding to the impulsive screw is known. In the special case where the freedom degrades to the rotation around a point, the problem now before us reduces to that solved in Poinsot's celebrated memoir.

We have first to draw the conic of which the equation is (*Screws*, p. 133)

$$u_1^2\,\theta_1^2 + u_2^2\,\theta_2^2 + u_3^2\,\theta_3^2 = 0.$$

This conic is of course imaginary, being in fact the locus of screws about which, if the body were twisting with the unit of twist velocity, the kinetic energy would nevertheless be zero. If two points θ, ϕ are conjugate with respect to this conic, then

$$u_1^2\,\theta_1\,\phi_1 + u_2^2\,\theta_2\,\phi_2 + u_3^2\,\theta_3\,\phi_3 = 0.$$

The screws corresponding to θ and ϕ are then what we have called *conjugate screws of inertia.*

This conic is referred to a self-conjugate triangle, the vertices of which are three conjugate screws of inertia. It is possible to find one self-conjugate triangle to the zero-pitch conic, and to the conic of inertia just considered. The vertices of this triangle are of especial interest. Each pair of them correspond to a pair of screws which are reciprocal, as well as being conjugate screws of inertia. They are therefore what we have designated as the *principal screws of inertia* (*Screws*, chapter VI.). They degenerate to the principal axes of the body when the freedom degenerates to the special case of the rotation around a fixed point.

When referred to this self-conjugate triangle, the relation between the impulsive point and the corresponding instantaneous point can be expressed with great simplicity. Thus the impulsive point ϕ, whose co-ordinates are

$$\theta_1\,u_1^2 \div p_\alpha;\quad \theta_2\,u_2^2 \div p_\beta;\quad \theta_3\,u_3^2 \div p_\gamma,$$

corresponds to the instantaneous point whose co-ordinates are θ_1, θ_2, θ_3. The geometrical construction is extremely simple when derived from the theorem thus stated.

If ϕ denote an impulsive screw, and θ denote the corresponding instantaneous screw, then the polar of ϕ with regard to the zero-pitch

conic is the same straight line as the polar of θ with regard to the inertia conic.

If H be the virtual coefficient of two screws θ and η, then

$$H^2(\theta_1^2+\theta_2^2+\theta_3^2) = (p_\alpha\theta_1\eta_1+p_\beta\theta_2\eta_2+p_\gamma\theta_3\eta_3)^2.$$

It follows that the locus of the points which have a given virtual coefficient with a given point is a conic[2] touching the conic of infinite pitch at two points. If ψ be the screw whose polar with regard to the infinite-pitch conic is identical with the polar of η with regard to the zero-pitch conic, then all the screws θ which make a given virtual coefficient with η are equally inclined to ψ. It hence follows that all the screws of a three-system which have a given virtual coefficient with a given screw are parallel to the generators of a right circular cone. All the screws reciprocal to η form a cylindroid, and ψ is the one screw of the system which is parallel to the nodal line of the cylindroid. The virtual coefficient of ψ and η is greater than that of η with any other screw.

If θ be a screw about which, when the body is twisting with a given twist velocity it has a given kinetic energy, then we must have

$$u_1^2\theta_1^2+u_2^2\theta_2^2+u_3^2\theta_3^2-h^2(\theta_1^2+\theta_2^2+\theta_3^2)=0,$$

where h^2 is a constant proportional to the energy. It follows that the locus of θ must be a conic constantly passing through the four points of intersection of

$$u_1^2\theta_1^2+u_2^2\theta_2^2+u_3^2\theta_3^2=0,$$
$$\theta_1^2+\theta_2^2+\theta_3^2=0.$$

The four points in which these two conics intersect correspond to the screws about which the body can twist with indefinite kinetic energy. These four points A, B, C, D being known, the kinetic energy appropriate to every point P can be readily ascertained. It is only necessary to measure the anharmonic ratio subtended by P, at A, B, C, D, and to set off distances u_1^2, u_2^2, u_3^2, h^2 on a straight line, so that the anharmonic ratio of the four points shall be equal to that subtended by P. This will determine h^2, which is proportional to the kinetic energy of the unit twist velocity about the screw corresponding to P.

A quiescent rigid body of mass M receives an impulsive wrench of given intensity on a given screw η; determine the locus of the screw θ belonging to the three-system, such that if the body be constrained to twist about θ, it shall acquire a given kinetic energy.

[2] The non-Euclidian geometer will regard all such conics as "circles."

It follows at once (*Theory of Screws*, p. 136) that we must have

$$H(u_1^2\theta_1^2 + u_2^2\theta_2^2 + u_3^2\theta_3^2) = (p_\alpha\theta_1\eta_1 + p_\beta\theta_2\eta_2 + p_\gamma\theta_3\eta_3)^2,$$

where H is proportional to the kinetic energy. The required locus is therefore a conic having double contact with the inertia conic.

It is easy to prove from this that H will be a maximum if

$$u_1^2\theta_1 : p_\alpha\eta_1 = u_2^2\theta_2 : p_\beta\eta_2 = u_3^2\theta_3 : p_\gamma\eta_3;$$

whence we have Euler's well-known theorem that if the body be allowed to select the screw about which it will twist, the kinetic energy acquired will be larger than when the body is constrained to a screw other than that which it naturally chooses.

A somewhat curious result arises when we seek the interpretation of a tangent to the infinite pitch conic. This tangent must, like any other straight line, correspond to a cylindroid; and since it is the polar of the point of contact, it follows that every screw on the cylindroid must be at right angles to the direction corresponding to the point of contact. The co-ordinates of the point of contact must therefore be proportional to the direction cosines of the nodal line of the cylindroid.

If the body be in equilibrium under the action of a conservative system of forces, then there is a conic (analogous to the conic of inertia) which denotes the locus of screws about which the body can be displaced to a neighbouring position, so that even as far as the second order of small quantities no energy is consumed. The vertices of the common self conjugate triangle of this conic and the conic of inertia correspond to the harmonic screws about which, if the body be once displaced, it will continue for ever to oscillate.

The further development of the subject, on which this Paper is a preliminary note, must form the basis of a future and more extensive memoir.

—On Homographic Screw Systems. By Robert S. Ball, LL.D., F.R.S.

[Read, May 9th, 1881.]

e lately ascertained that several of the most important parts of *'heory of Screws* can be embraced in a more general theory. I se in the present Paper to sketch this general theory. It will be to have points of connexion with the modern higher geometry; ticular the theory of Homographic Screws is specially connected he general theory of correspondence. I believe it will be of nterest to show how these abstract geometrical theories may be ated by dynamics. The intimate alliance which exists between igher branches of rigid dynamics and the higher branches of n geometry is perfectly natural. This will, I hope, be sufficiently ated in the present Paper. Among the more recondite theorems id dynamics is that of the existence of a number of principal s of inertia equal to the number of degrees of freedom which the enjoys. Yet we shall show in this Paper that this is an instanas consequence of the purely geometrical theory of homographic s.

e commence with the most general case in which the screws may arded as existing anywhere in space. I may remind the reader *screw* in the present sense of the word denotes a right line of ed situation and direction with which the linear magnitude d the *pitch* is associated.

ven one screw α, it is easy to conceive that another screw β correing thereto shall be also determined. We may, for example, se that the co-ordinates of β (see *Theory of Screws*, p. 33) shall ren functions of those of α, or we may imagine a geometrical uction by the aid of fixed lines or curves by which, when an α is the corresponding β shall be forthwith known: again, we may ne a connexion involving dynamical conceptions such as that, α is the seat of an impulsive wrench, β is the instantaneous about which the body begins to twist.

α moves about, so will the corresponding screw β: we thus have *rresponding screw systems* generated. Regarding the connexion en the two systems from a purely analytical point of view, the inates of α and β will be connected by certain equations. It will nerally happen that a single screw β corresponds to a single α, and that conversely a single screw α corresponds to a single β; but *when this does happen the two systems of screws are said omographic.*

screw α in the first system has one corresponding screw β in ond system; so also to β in the second system corresponds one α' in the first system. It will generally be impossible for α and

but cases may arise in which they do coincide, and these sed further on.

fundamental property of two homographic screw systems t the co-ordinates of β must be expressed by six equations

$$\beta_1 = f_1(\alpha_1, \ldots \alpha_6)$$
&c., &c.,
$$\beta_6 = f_6(\alpha_1, \ldots \alpha_6).$$

six equations be solved for α . . . α_6 we must have—

$$\alpha_1 = F_1(\beta \ldots \beta_6)$$
&c.,
$$\alpha_6 = F_6(\beta_1, \ldots \beta_6).$$

easily shown, that if $\alpha_1, \alpha_2 \ldots \alpha_6$ are to have unique values, se equations must be linear; whence we have the following nt result:—

two homographic screw systems the co-ordinates of a screw in one are linear functions with constant coefficients of the co-ordinates of the corresponding screw in the other system.

If we denote the constant coefficients by the notation (11) (22), &c., then we have the following system of equations:—

$$\beta_1 = (11)\alpha_1 + (12)\alpha_2 + (13)\alpha_3 + (14)\alpha_4 + (15)\alpha_5 + (16)\alpha_6,$$
$$\beta_2 = (21)\alpha_1 + (22)\alpha_2 + (23)\alpha_3 + (24)\alpha_4 + (25)\alpha_5 + (26)\alpha_6,$$
&c.,
$$\beta_6 = (61)\alpha_1 + (62)\alpha_2 + (63)\alpha_3 + (64)\alpha_4 + (65)\alpha_5 + (66)\alpha_6.$$

It is now easy to show that there are six screws which coincide with their corresponding screws; for if $\beta_1 = \rho\alpha_1$, $\beta_2 = \rho\alpha_2$, &c., we obtain an equation of the sixth degree for the determination of ρ. We therefore have the following result:—

In two homographic screw systems six screws can be found, each of which regarded as a screw in either system coincides with its correspondent in the other system.

In two homographic rows of points we have the anharmonic ratio of any four points equal to that of their correspondents. In the case of two homographic screw systems we have a set of eight screws in one of the systems specially related to the corresponding eight screws in the other system.

We first remark that, given seven pairs of corresponding screws in the two systems, then the screw corresponding to any other

given screw is determined. For from the six equations just written by substitution of known values of $\alpha_1 \ldots \alpha_6$ and $\beta_1 \ldots \beta_6$, we can deduce six equations between (11), (12), &c. As, however, the co-ordinates are homogeneous and their ratios are alone involved, we can only use the ratios of the equations so that each pair of screws gives five relations between the 36 quantities (11), (12), &c. The seven pairs thus give 35 relations which suffice to determine linearly the ratios of the coefficients. The screw β corresponding to any other screw α is completely determined; we have therefore proved that—

When seven corresponding pairs of screws are given, the two homographic screw systems are completely determined.

A perfectly general way of conceiving two homographic screw systems may be thus stated:—Decompose a wrench of given intensity on a screw α into wrenches on six arbitrary screws. Multiply the intensity of each of the six component wrenches by an arbitrary constant; construct the wrench on the screw β which is the resultant of the six components thus modified; then as α moves into every position in space, and has every fluctuation in pitch, so will β trace out the homographic screw system.

It is easily seen that in this statement we might have spoken of twist velocities instead of wrenches.

The seven pairs of screws of which the two systems are defined cannot be always chosen arbitrarily. If, for example, three of the screws were co-cylindroidal, then the three corresponding screws must also be co-cylindroidal, and can only be chosen arbitrarily subject to this imperative restriction. More generally we shall now prove that if any $n+1$ screws belong to an n-system (*Screws*, p. 38), then the $n+1$ corresponding screws will also belong to an n-system. If $n+1$ screws belong to an n-system it will always be possible to determine the intensities of certain wrenches on the $n+1$ screws which when compounded together will equilibrate. The conditions that this shall be possible are easily expressed. Take, for example, $n=3$, and suppose that the four screws $\alpha, \beta, \gamma, \delta$ are such that suitable wrenches on them, or twist velocities about them, neutralize. It is then obvious (see *Screws*, ch. V.) that each of the determinants must vanish which is formed by taking four columns from the expression—

$$\left|\begin{array}{cccccc} \alpha_1, & \alpha_2, & \alpha_3, & \alpha_4, & \alpha_5, & \alpha_6, \\ \beta_1, & \beta_2, & \beta_3, & \beta_4, & \beta_5, & \beta_6, \\ \gamma_1, & \gamma_2, & \gamma_3, & \gamma_4, & \gamma_5, & \gamma_6, \\ \delta_1, & \delta_2, & \delta_3, & \delta_4, & \delta_5, & \delta_6; \end{array}\right|$$

but it is easy to see that these determinants will equally vanish for the corresponding screws in the homographic system; for if we take for

six common screws of the two systems, then we have at o-ordinates of the screw corresponding to a—

$$(11)\,a_1, \quad (22)\,a_2, \quad (33)\,a_3, \quad (44)\,a_4, \quad (55)\,a_5, \quad (66)\,a_6.$$

ese substitutions are made in the determinants it is obvious still vanish; we hence have the important result that

screws corresponding homographically to the screws of an n-system n another n-system.

Thus to the screws on a cylindroid will correspond the screws on ndroid. It is, however, important to notice that two reciprocal have not in general two reciprocal screws for their correspon- We thus see that while two reciprocal screw systems of the n^{th} ... $- n^{th}$) orders respectively have as correspondents systems of e orders, yet that their connexion as reciprocals is divorced by ographic transformation.

eciprocity is not therefore an invariantive attribute of screws or screw systems. There are, however, certain functions of eight screws analogous to anharmonic ratios which are invariants. These functions are of considerable interest, and they are not without physical significance.

We have already (*Screws*, p. 163) discussed the important function of six screws which is called the *Sexiant*. This function is most concisely written as the determinant $(a_1\,\beta_2\,\gamma_3\,\delta_4\,\epsilon_5\,\zeta_6)$ where $a, \beta, \gamma, \delta, \epsilon, \zeta$, are the screws. In Sylvester's language we may speak of the six screws as being in *involution* when their sexiant vanishes. Under these circumstances six wrenches on the six screws can equilibrate; the six screws all belong to a 5-system, and they possess one common reciprocal. In the case of eight screws we may use a very concise notation; thus $\overline{12}$ will denote the sexiant of the six screws obtained by *leaving out* screws 1 and 2. It will now be easy to show that functions of the following form are invariants:—

$$\frac{\overline{12}\,.\,\overline{34}}{\overline{13}\,.\,\overline{24}}.$$

It is in the first place obvious that as the co-ordinates of each screw enter to the same degree in the numerator and the denominator, no embarrassment can arise from the arbitrary common factor with which the six co-ordinates of each screw may be affected. In the second place it is plain that if we replace each of the co-ordinates by those of the corresponding screw, the function will still remain unaltered, as all the factors (11), (22), &c., will divide out. We thus see that the function just written will be absolutely unaltered when each screw is changed into its corresponding screw.

By the aid of these invariant functions it is easy, when seven pairs of screws are given, to construct the screw corresponding to any given eighth screw. We may solve this problem in various ways. One of the simplest will be to write the five invariants

$$\frac{\overline{12}\cdot\overline{38}}{\overline{13}\cdot\overline{28}},\quad \frac{\overline{13}\cdot\overline{48}}{\overline{14}\cdot\overline{38}},\quad \frac{\overline{14}\cdot\overline{58}}{\overline{15}\cdot\overline{48}},\quad \frac{\overline{15}\cdot\overline{68}}{\overline{16}\cdot\overline{58}},\quad \frac{\overline{16}\cdot\overline{78}}{\overline{17}\cdot\overline{68}}.$$

These can be all computed from the given eight screws of one system; hence we have five linear equations to determine the ratios of the coefficients of the required eighth screw of the other system.

It would seem that of all the invariants of eight screws, five alone can be independent. These five invariants are attributes of the eight-screw system, in the same way that the anharmonic ratio is an attribute of four collinear points. The curious inquirer may be tempted to speculate on the analogy between a group of eight screws which satisfy one or more of the conditions

$$\overline{12}\cdot\overline{38}+\overline{13}\cdot\overline{28}=0,$$

and a row of four points, whereof two cut the other pair harmonically.

The invariants are also very easily deduced by considerations of a mechanical nature. It is not hard to conceive that to a dyname on one screw corresponds a dyname on the corresponding screw, and that the ratio of the intensities of the two dynames is to be independent of their intensities. We may take a particular case to illustrate the argument :—Suppose a free rigid body to be at rest. If that body be acted upon by an impulsive system of forces, those forces will constitute a wrench on a certain screw α. In consequence of these forces the body will commence to move, and its instantaneous motion cannot be different from a twist velocity about some other screw β. To one screw α will correspond one screw β, and (since the body is perfectly free) to one screw β will correspond one screw α. It follows, from the definition of homography, that as α moves over every screw in space, β will trace out an homographic system. . . . From the laws of motion it will follow, that if F be the intensity of the impulsive wrench, and if V be the twist velocity which that wrench evokes, then $F\div V$ will be independent of F and V, though, of course, it is not independent of the actual position of α and β.

It is known (*Screws*, p. 171) that when seven wrenches equilibrate (or when seven twist velocities neutralize), the intensity of the wrench (or the twist velocity) on any one screw must be proportional to the sexiant of the six non-corresponding screws.

, &c., F_{78} be the intensities of seven impulsive wrenches 1, 2, . . . 7, which equilibrate, then we must have

$$\frac{F_{18}}{\overline{18}} = \frac{F_{28}}{\overline{28}} = \&c. = \frac{F_{78}}{\overline{78}}.$$

y, by omitting the first screw, we can have seven impulsive ...es which equilibrate, where

$$\frac{F_{12}}{\overline{12}} = \frac{F_{13}}{\overline{13}} = \frac{F_{14}}{\overline{14}} = \&c. = \frac{F_{18}}{\overline{18}};$$

we have

$$\frac{\overline{12} \cdot \overline{38}}{\overline{12} \cdot \overline{28}} = \frac{F_{12} \cdot F_{38}}{F_{13} \cdot F_{28}}.$$

Let the instantaneous twist velocity corresponding to F_{18} be denoted by V_{18}, then, as when seven wrenches equilibrate, the seven corresponding twist velocities must also equilibrate, we must have in the corresponding system,

$$\frac{\overline{12} \cdot \overline{38}}{\overline{13} \cdot \overline{28}} = \frac{V_{12}\ V_{38}}{V_{13}\ V_{28}}.$$

But we must have the twist velocity proportional to the impulsive intensity; hence, from the second pair of screws we have

$$F_{28} : V_{28} :: F_{12} : V_{12},$$

and from the third pair,

$$F_{38} : V_{38} :: F_{13} : V_{13};$$

hence we deduce

$$\frac{V_{12} \cdot V_{38}}{V_{13}\ \ V_{28}} = \frac{F_{12} \cdot F_{38}}{F_{13}\ \ F_{28}},$$

and, consequently, the function of the eight impulsive screws,

$$\frac{\overline{12} \cdot \overline{38}}{\overline{13} \cdot \overline{28}},$$

must be identical with the same function of the instantaneous screws.

It should, however, be remarked, that the impulsive and instantaneous screws do not exhibit the most general type of two homographic systems. A more special type of homography, and one of very great interest, characterizes the two sets of screws referred to. As

this special type is also of importance for other kinetic problems, it will be desirable to examine into its general character.

If the general linear transformation, which changes each screw α into its correspondent θ, be specialized by the restriction that the co-ordinates of θ are given by the equations

$$\theta_1 = \frac{1}{p_1}\frac{dU}{d\alpha_1},$$

$$\theta_2 \quad \frac{1}{}\frac{dU}{}$$

$$\theta_6$$

where U is any homogeneous fu order in $\alpha_1, \ldots \alpha_6$, and where $p_1, \ldots p_6$ are the p s of reference, then the two systems are related b of homography to which I have referred.

The fundamental property o mographic systems is thus stated :—

Let α and β be any two scre be their correspondents, then, when α is reciprocal procal to θ.

We may, without loss of ge hat the screws of reference are co-reciprocal, and i condition that β and θ shall be co-reciprocal is

$$p_1\beta_1\theta_1 + p_2\beta_2\theta_2 - \ldots + p_6\beta_6\theta_6 = 0 ;$$

but by substituting for $\theta_1 \ldots \theta_6$, this condition reduces to

$$\beta_1 \frac{dU}{d\alpha} + \ldots + \beta_6 \frac{dU}{d\alpha} = 0.$$

Similarly, the condition that α and ϕ shall be reciprocal is

$$\alpha_1 \frac{dU}{d\beta_1} + \ldots + \alpha_6 \frac{dU}{d\beta_6} = 0.$$

It is obvious that as U is an homogeneous function of the second degree, these two conditions are identical, and the required property has been proved.

It is easily shown that by suitable choice of the screws of reference the function U may, in various ways, be reduced to the sum of six square terms. We now proceed to show that this reduction is pos-

...ay, while still retaining six co-reciprocals for the screws ...nce.

... pitch p_a of the screw α is given by the equation (*Screws*,

$$p_a = p_1\alpha_1^2 + \ldots + p_6\alpha_6^2 :$$

... screws of reference being co-reciprocals, the function p_a must ...he same form after the transformation of the axes. The dis-...inant of the function

$$U + \lambda p_a$$

...ated to zero will give six values of λ; these values of λ will de-...mine the coefficients of U in the required form. I do not, however, ...ter further into the discussion of this question, which belongs to the ...eneral theory of linear transformations.

The transformation having been effected, an important result is ...mediately deduced. Let the transformed equation be denoted by

$$(11)\,\alpha_1^2 + \ldots + (66)\,\alpha_6^2 = 0,$$

then we have

$$\beta_1 = \frac{1}{p_1}(11)\,\alpha_1,$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot$$

$$\beta_6 = \frac{1}{p_6}(66)\,\alpha_6;$$

whence it appears that the six screws of reference are the common screws of the two systems. We thus find that in this special case of homography

The six common screws of the two systems are co-reciprocal.

It is proved (*Screws*, p. 48) that the correspondence between impulsive screws and instantaneous screws is of the type here referred to. The six common screws of the two systems are therefore what we have called the *principal screws of inertia*, and they are co-reciprocal.

The special circumstances under which a screw α has the same correspondent, whichever of the two systems α be regarded as belonging to, demands a few words. If we take the six common screws of the two systems as the screws of reference, then the condition stated can only be fulfilled when the relation has the form

$$\beta_1 = \pm\, \alpha_1,$$

$$\cdot \quad \cdot \quad \cdot$$

$$\beta_6 = \pm\, \alpha_6.$$

For example, if

$$+\alpha_1,\quad +\alpha_2,\quad +\alpha_3,\quad +\alpha_4,\quad +\alpha_5,\quad +\alpha_6$$

be the co-ordinates of one screw, and if

$$-\alpha_1,\quad +\alpha_2,\quad +\alpha_3,\quad +\alpha_4,\quad +\alpha_5,\quad +\alpha_6$$

be the corresponding screw, then the two systems will fulfil the required condition. We thus have a kind of screw involution analogous to what is known as the relation of involution between the rows of points on the same line.

If we add the further restriction, that the six common screws are co-reciprocal, the homography is then of a very special type. The pitch of each screw,

$$p_1\alpha_1^2 + \ldots + p_6\alpha_6^2,$$

is equal to that of the corresponding screw, and the virtual coefficient,

$$p_1\alpha_1\beta_1 + \ldots + p_6\alpha_6\beta_6,$$

of two screws is equal to that of the two corresponding screws. In the particular case, when the virtual coefficient is zero, we see that if two screws be reciprocal, so are also the two corresponding screws. The angle ϕ between two screws is, however, not preserved; for, as shown elsewhere, [1]

$$\cos\phi = \Sigma\alpha_1\beta_1 + \Sigma(\alpha_1\beta_2 + \alpha_2\beta_1)\, h_{12},$$

when h_{12} is the cosine of the angle between the two screws of reference, 1 and 2. Cos ϕ is thus altered when the signs of α_1 and β_1 are changed. It is also evident that the perpendicular distance d between the two screws is altered, for the virtual coefficient is

$$(p_\alpha + p_\beta)\cos\phi - d\sin\phi.$$

We have seen that this function, as well as p_α and p_β, remain unaltered; hence, since ϕ is changed, we must also have d changed. I have not hitherto seen any instance in which this highly specialized form of homography is presented in a physical question.

There is a form of correspondence, very frequently of importance, which must now be considered in detail. For the sake of illustration, suppose a body which is at rest, and which has two degrees of freedom, be struck by any impulsive system of forces. These forces may constitute a wrench of any pitch, and anywhere, yet the movement

[1] *Transactions* of this Academy, vol. xxv. p. 306.

body can accept is limited, and the body can, indeed, only about one of the singly infinite number of screws which constitute the cylindroid. To any screw in space will correspond one screw on the cylindroid. But will it be correct to say, that to one screw on the cylindroid corresponds one screw in space? The fact is, that there is a quadruply infinite number of screws, an impulsive wrench on any one of which will make the body choose the same screw on the cylindroid for its instantaneous movement. The relation of this quadruply infinite group is well known in the *Theory of Screws.* It is shown (*Screws*, p. 110) that, given a screw α on the cylindroid, there is one screw θ on the cylindroid, an impulsive wrench on which will make the body commence to twist about α. It is further shown that any screw whatever which fulfils the single condition of being reciprocal to a single specified screw on the cylindroid possesses the same property. The screws thus form a 5-system. The correspondence at present before us is therefore to be thus stated—

To one screw in space corresponds one screw on the cylindroid, and to one screw on the cylindroid corresponds a 5-system in space.

We may look at the matter in a more general manner. Consider an m-system (A) of screws, and an n-system (B) ($m > n$). If we make $m = 6$ and $n = 2$, this system includes the system we have been just discussing. To one screw in A will correspond one screw in B, but to one screw in B will correspond, not a single screw in A, but an $(m + 1 - n)$ system of screws.

If $m = n$, we find that one screw of one system corresponds to one screw of the other system. Thus, if $m = n = 2$, we have a pair of cylindroids, and one screw on one cylindroid corresponds to one screw on the other. A set of four screws on a cylindroid, being all parallel to a plane, we may speak of the anharmonic ratio of four co-cylindroidal screws, and we obtain the result that it is equal to the anharmonic ratio of the four corresponding screws (*Screws*, p. 106). If $m = 3$, and $n = 2$, we see that to each screw on the cylindroid will correspond a whole cylindroid of screws belonging to the 3-system. For example, if a body have freedom of the second order, a whole cylindroid full of screws can always be chosen from any 3-system, an impulsive wrench on any one of which will make the body commence to twist about the given screw.

The property of the screws common to the two homographic systems will of course require some modification when we are only considering an m-system and an n-system. Let us take the case of a 3-system on the one hand, and a 6-system, or all the screws in space, on the other hand. To each screw α of the 3-system A must correspond, a 4-system, B in space. The screws of this 4-system are in such profusion, that a whole cone full of them can be drawn through every point in space. Amid this multitude it is most interesting to note that one screw β can be found, which, besides belonging to B, belongs also to A. Take any two screws reciprocal to B, and any

three screws reciprocal to A, then the single screw β, which is reciprocal to the five screws thus found, belongs to both A and B. We thus see that to each screw α of A, one corresponding screw in the same system can be determined. The result just arrived at can be similarly shown generally, and thus we find that when every screw in space corresponds to a screw of an n-system, then each screw of the n-system will correspond to a $(7-n)$ system, and among the screws of this system one can always be found which lies on the original n-system.

As a mechanical illustration of this result we may refer to the theorem, that if a rigid body has freedom of the n^{th} order, then, no matter what be the system of forces which act upon it, we may always combine the resultant wrench with certain reactions of the constraints, so as to produce a wrench *on a screw of the n-system* which defines the freedom of the body, and this wrench will be dynamically equivalent to the given system of forces.

It is easy to state the matter analytically, and for convenience we shall take a 3-system, though it will be obvious that the process is quite general.

Of the six screws of reference, let three screws be chosen on the 3-system, then the co-ordinates of any screw on that system will be $\alpha_1, \alpha_2, \alpha_3$, the other three co-ordinates being equal to zero. The co-ordinates of the corresponding screw β must be indeterminate, for any screw of a 4-system will correspond to β. This provision is secured by $\beta_4, \beta_5, \beta_6$ remaining quite arbitrary, while we have for $\beta_1, \beta_2, \beta_3$ the definite values,

$$\beta_1 = (11)\,\alpha_1 + (12)\,\alpha_2 + (13)\,\alpha_3,$$

$$\beta_2 = (21)\,\alpha_1 + (22)\,\alpha_2 + (23)\,\alpha_3,$$

$$\beta_3 = (31)\,\alpha_1 + (32)\,\alpha_2 + (33)\,\alpha_3.$$

If we take $\beta_4, \beta_5, \beta_6$, all zero, then the values of $\beta_1, \beta_2, \beta_3$, just written, give the co-ordinates of the special screw belonging to the 3-system, which is among those which correspond to α.

As α moves on the 3-system, so will the other screw of that system which corresponds thereto. There will, however, be three cases in which the two screws coincide; these are found at once by making

$$\beta_1 = \rho\alpha_1; \quad \beta_2 = \rho\alpha_2; \quad \beta_3 = \rho\alpha_3,$$

whence we obtain a cubic for ρ.

It is thus seen that generally n screws can be found on an n-system, so that each screw shall coincide with its correspondent. As a dynamical illustration we may give the important theorem, that when a rigid body has n degrees of freedom, then n screws can always be found, about any of which the body will commence to twist when it

receives an impulsive wrench on the same screw. These screws are the principal screws of inertia.

We have already seen the anharmonic equality between four screws on a cylindroid, and the four corresponding screws; we have also shown a sort of *quasi* anharmonic equality between any eight screws in space and their correspondents. More generally, any $n + 2$ screws of an n-system are connected with their $n + 2$ correspondents, by relations which are analogous to anharmonic properties. The invariants are not generally so simple as in the 8-screw case, but we may state them, at all events, for the case of $n = 3$.

Five screws belonging to a 3-system, and their five correspondents are so related, that, given nine of them, the tenth is immediately determined; for this two data are required, that being the number required to specify a screw already known to belong to a given 3-system.

We may, as before, denote by $\overline{12}$ the condition that the screws 3, 4, 5 shall be co-cylindroidal. This, indeed, requires no less than four distinct conditions, yet, as pointed out (*Screws*, p. 44), functions can be found whose evanescence will supply all that is necessary. Nor need this cause any surprise, when it is remembered that the evanescence of the sine of an angle between two lines contains the two conditions necessary that the direction cosines are identical. The function

$$\frac{\overline{12} \cdot \overline{34}}{\overline{13} \cdot \overline{24}}$$

can then be shown to be an invariant which retains its value unaltered when we pass from one set of five screws in a 3-system to the corresponding set in the other system. When two invariants are known, the required screw is determined.

LXVI. REPORT ON THE CLEARING OF PEATY WATERS. PART I. By GERRARD A. KINAHAN.

[Read, May 9th, 1881.]

Introduction.

IN the spring of 1880 Professor Hartley, F.R.S.E., suggested that I should make certain experiments on peaty waters, as he had observed that some peaty streams become rapidly decolourized, while others flow for considerable distances without undergoing any alteration. Besides furnishing me with some observations and the results of some experiments he had made, he desired me to direct my attention specially to the action of clays, and the more commonly occurring lime salts, in order to determine whether they or natural oxidation of the peaty matter played the more important part in the decolourizing of peaty streams.

Professor Hartley had remarked that along the course of the River Affaric, in Invernesshire, flowing from Loch Affaric through Loch Benevian to join the River Glass, a distance of about six miles over a hard rocky bed (quartzite, micaceous schist, and basalt), no alteration in the colour of the water was detected, though for three weeks while the observations were carried on no rain fell, and there was abundance of sunshine, the stream being frequently lashed into foam along its course.

He found that peaty waters can be partially purified by an admixture of hard water of about 26° of hardness on Clarke's scale. Also that when a mixture of hard water and soft peaty water was softened by adding lime water, the calcic carbonate carried down much peaty colouring matter, the purification being more effectual than in the last case.

He ascertained also that about two to three grains of sulphate of alumina were sufficient to decolourize ten gallons of darkish peaty water, the dark brown matter settling down in about twenty-four hours. From this it might be anticipated, as was actually proved by experiment, that certain clays, when mixed with the water, would have a similar effect.

Professor Hartley also remarks that Mr. J. Y. Buchanan, late of the scientific staff of the Challenger, has found that the water at the bottom of some of the Highland Lochs is colourless, while the surface water is peaty; the material at the bottom being blue or white clay. One particular instance of this occurs at Loch Ness, in places where the water is from 50 to 110 fathoms deep.

In this Report I propose to give, first, the field notes made on streams in the Ovoca river basin, with the results of some of my laboratory experiments suggested by these observations, to which are added some notes on the inferences to be drawn from both.

The experiments in the laboratory were carried on, more or less simultaneously with the observations in the field on peaty streams; notes on the latter being supplemented by experiments in the former.

Observations on Peaty Streams.

These observations were made almost solely on the waters of the Ovoca river basin, and principally on those of its tributaries, the Ow and the Avonbeg.

The rocks occurring in this basin are granite, clay slate more or less metamorphosed, with a few thin bands of limestone, and patches of eruptive rocks. The superficial coverings to these are the *drifts*, whether glacial, which may have been transported from some distance, and contain foreign substances; or meteoric, due to the disintegration of the underlying rocks; gravels, occurring principally in the valleys; and peat, found on the mountain slopes and in some places in the valleys.

From this it would appear that in this river basin for the most part there is an absence of rocks yielding carbonate of lime, or lime salts; the sources from which these might be derived being the few fragments of limestone in the glacial drifts, the marls, which are rare, the few bands of limestone scattered through the slates, and the eruptive ashes containing crystallized calcite.

Thus the waters of this district may be classified generally as very soft waters, with a few small local exceptions.

Along the main streams (Ow and Avonbeg), the depth of tint of the colouring varied greatly, from local causes such as the state of a tributary; but in a few cases the variations are, as yet, inexplicable. The most satisfactory results were not, therefore, obtained from these larger streams, but from their tributaries; and of these, one of the most interesting and instructive is the Ballynagappoge brook.

It had been noticed that, as a rule, in any peaty stream the waters were more darkly coloured at the head waters than anywhere lower down; therefore, when examining the variations in the amount of colouring along the course of a stream, the method usually adopted was as follows:—Starting from the head with a sample of the water, we proceeded down stream, till some alteration in the state of the stream occurred; this might be due to the junction with another stream, or an alteration in the river bed, such as a marked change in the rate of fall, or the occurrence of clay or gravel. Here a second sample of water was taken, and compared with the first, by placing both side by side in two similar tumblers on a white surface, the differences in depth of tint being then noted; proceeding down stream with these two samples, the next comparison was made where the next remarkable change took place; if the depth in tint here was very different from the last, the second sample was discarded, and this third carried down for comparison at the next point of observation, the first, or the sample

taken at the head waters, being always retained for comparison along the course, but more particularly with a sample taken where the stream joined the main river. In the small brooks or tributaries the waters cleared going down stream, but in the larger rivers very irregular changes often occur, their waters being affected by the character of each of the tributaries.

The thickness of the stratum examined in the tumblers was about 4½ inches; which was found sufficient for all purposes in the field, as a very slight alteration in the colour could be detected; but for more detailed and accurate purposes in the laboratory a thicker stratum is desirable.

In these peaty waters there appear to be two distinct colouring matters, one producing a brown of various degrees of intensity, the other an olive-green;[1] the mixture of the two colouring matters in proper proportion produces a brown-green, but as a general rule the former obscures the latter.

It may be here pointed out that no correct estimate of the alterations in the depth of tint of peaty colouring matter that take place along the course of a stream can be formed by only looking at the waters in the stream; because the thickness of the stratum of water looked at, *i. e.* the depth of the river, may change, and the bottom of the river may be variously coloured: some marked changes, however, may be detected by observing the difference in the colour of the foam that forms at the different small falls along a stream.

By the method as sketched out above, the principal tributaries belonging to the Ow and Avonbeg were carefully examined from their head waters to their junction with the main rivers, and their effect on each main river, if any, was noted. This was done by comparing a sample taken from the main river just above where it was joined by the tributary, with one taken below the first fall or rapid that occurred after their junction, where their waters would be well mixed.

The examination of the streams was repeated during different stages of flood, and different seasons of the year. It appears that, as a rule, the streams are more peaty in summer than in winter; and that after continuous dry weather the peaty matter is much reduced. During cold frosty weather, or when there is snow on the mountains, very little peaty colouring is found in the streams.

The Ballynagappoge brook, which drains the N.W. slope of Croaghanmoira and discharges into the Ow, affords, as previously pointed out, much instruction. When examined during the summer it was found at its head waters to be of a deep brown, but when it joined the Ow after a flow of about 1½ miles with a fall of about 500 feet it had become quite clear and limpid; all its feeders are peaty, except a small one that enters it below Rosahane-bridge after the principal decolourization has taken place. This brook therefore may be described in detail.

[1] I find that Dr. Tidy states (*Chem. Soc. Jour.*, 1880, p. 293), that the *brown* colour is due to old peat, the *olive-green* to more recent peaty matter.

The head waters above Ballynagappoge bridge are deeply tinted with peaty colouring matter; the bed of the stream here is marshy, with a slaty rock appearing in places; below the bridge there is more rock, less marsh, while a little gravelly clay appears in places; some distance down, the stream is joined by another of about equal size and about equally coloured, but which has been flowing along a somewhat gravelly bed. Just before its junction with this stream the brook had not so deep a colour as it had at Ballynagappoge bridge. The united streams wash against the foot of a blue clayey cliff, from which a considerable quantity of clay is evidently removed during flood time; below this cliff the bed of the stream is composed of a bare slaty rock with very little gravel resting upon it; the depth of tint of the water gradually but very slowly becomes reduced along this part of the course. Here the stream flows rapidly and forms a succession of little falls; this rocky bed, with its rapid fall, giving place at about 500 yards above Rosahane bridge to a clayey and gravelly bed with a reduced rate of fall. Between the point where this change occurs and the bridge the peaty colouring in the stream, which was considerable, is reduced to a mere trace, while a short distance below the bridge it is completely removed. Along this portion of the stream, just above the bridge, where the fall is slight, there are several marshy places from which iron-stained waters flow into the brook; this staining is due to the waters containing some ferrous salt (probably ferrous carbonate) in solution, which, on contact with the air, is decomposed or oxidized, depositing ferric hydrate or ochre. On the stones and in the pools about this part of the stream there is a dark brownish deposit; some of this was collected with the surrounding water, which had a slight peaty tinge. On standing, this water gave a yellow ferruginous precipitate, the water becoming most beautifully clear and limpid. It was found that the sediment collected consisted of a little sand and clay, with iron, alumina, magnesia, a little manganese and organic matter.

These iron springs appear to be the agents that, to a great extent, clear the waters; for although in all probability, clays in suspension, or the very small quantity of soluble matter that is dissolved out of them, will carry down a large amount of peaty colouring matter, yet, except when present in very large proportion, they seem incapable of decolourizing the waters completely.

The ferrous salts in these waters are probably derived from the reduction, by decomposing organic matter, of the ferric salts contained in the underlying rocks and clays.

The decolourizing of the waters of this brook is evidently not due to the direct oxidation of the peaty matter; nor is the diminution of the depth of tint due to dilution. In this stream it so happens that, where the fall is greatest, there the clearing of the water is least.

During December, 1880, it was remarked that the main rivers contained very little peaty colouring matter in them; about this time there had been slight frosts in the valleys, but upon the mountains there was

snow. On visiting the Ballynagappoge brook it was found that the waters were quite colourless and clear. Up to the head waters above Ballynagappoge-bridge no peaty colouring matter could be detected; the snow did not reach as low as this bridge.

It should be mentioned that though in cold weather little peaty colouring matter is in the streams, yet in the bog-holes (turf-holes) the water is quite brown.

The Carawaystick brook may be next described, as it is an example of a different class. Along its course very little diminution of the peaty tint occurs, though there is every facility for oxidation; the brook descending a height of about 1200 feet in a flow of less than two miles.

This brook flows from Kelly's lough, a small sheet of peaty water about eight acres in extent, on the S.E. slope of Lugnaquilla at an elevation of about 1700 feet above the sea. On the S.W. of the lough there is a granite cliff; the brook leaves the lough at the N.E. corner, flowing through the remains of an ancient glacial moraine in a north-westerly direction, for over a mile, with a slight inclination, then for the rest of its course (about half a mile) it descends a height of 700 feet (calculated by aneroid) over a bed composed of granite and schist, by a succession of falls and rapids, the waters being lashed into foam down nearly all that part of its course. From a comparison of samples taken both above and below the falls, no difference could be detected in the depth of tint of the waters.

During one of our visits, after there had been no rain for three or four days, it was remarked that the waters were not nearly so deeply coloured as on a previous visit, when showers were falling on the mountains. On this occasion, before ascending, a sample of water was taken at the foot of the falls, then about a cubic yard of a sandy clay was put into the stream above the fall, rendering it very turbid; then taking a second sample of water just above the turbidity, we descended to where the first had been taken from, and here after the turbid water had been flowing for some little time a third sample was taken. On comparing the samples subsequently, after the turbidity in No. 3 had completely subsided, this sample was darkest, while there was no apparent difference in tint between Nos. 1 and 2.

Along the Avonbeg the changes that occur are irregular, although on the whole there is a diminution in the depth of tint as we descend to the "Meeting of the Waters." Here it is joined by the Avonmore, and in a sample from this latter river, taken here in May, 1880, a small quantity of lead (0·028 parts per 100,000) was detected.

The united Rivers Avonmore and Avonbeg form the Ovoca, which a short distance down receives the waters from the Ovoca mines; first on its east or left bank, from the mines of Tigroney, Cronebane, and Connary; these containing ferrous sulphate, and sulphate of alumina in comparatively large proportions, with smaller quantities of other salts, as sulphate of copper, and arsenic. Lower down the river, coming in from the west or right bank, is the drainage of the Bally-

murtagh and Ballygahan mines. In a sample of water taken at the tail of the Landers, a litre of water was found to contain 0·81 grammes ferrous sulphate, and 0·78 grammes sulphate of alumina (equivalent to 56·8 grains ferrous sulphate, and 54·7 grains sulphate of alumina, per gallon), besides small quantities of arsenic and sulphate of copper, &c.

A sample of water taken from the Ovoca river, below, or after it had received these mineral waters, was very peaty when collected, and slightly turbid, but on standing some time a brown precipitate settled, with a considerable reduction of the tint; on another occasion, when the river was not so deeply tinted, by allowing a sample to settle for a time, the peaty colouring was completely removed, and in the laboratory about five cc. of the Ballygahan water cleared 250 cc. of a very peaty water; a dark brown precipitate first settling down, then a yellowish precipitate of ochre.

All along the Ovoca river, from the mines to its mouth in Arklow harbour, there is a ferruginous ochre deposited in the pools and on the stones; this being probably due to the ferrous salts in the waters becoming oxidised, this precipitation being accompanied by a considerable reduction of the peaty colouring matter in the river. A sample of water taken from the river below the place where this mine drainage enters is always found to contain a very finely divided precipitate of ochre which shortly settles out.

Though the Ovoca river is usually peaty, particularly during flood, it was remarked that in frosty weather, and when there was snow on the mountains, the peaty colouring was much reduced, and often entirely removed; the same was noticeable after a long continued drought, the river running perfectly colourless above the mines.

Experiments with Peaty Waters.

These experiments, commenced in the spring of 1880, and carried on under the direction of Professor Hartley, F.R.S.E., in his laboratory at the Royal College of Science for Ireland, had for their object the determination of the agents that may effect the decolourisation of peaty waters, more especially of those that actually effect it in nature.

As clays occur in some form or other along the beds and banks of most streams, and as during floods they become suspended in the waters to a greater or less extent, some of the first experiments were made with such clays.

Specimens were obtained, principally from the County Wicklow, of disintegrating argillaceous rocks and clays; many of these, however, were subsequently rejected, as it was found that they contained organic matter sufficient to discolour the water and obscure their action on the peaty colouring matter in it.

In each experiment a measured quantity of water was shaken up with a weighed quantity of clay, then left to allow the substances in suspension to subside. When the water had cleared, a portion was decanted off and placed in a tall narrow cylinder; in some of the experiments

the cylinder used was 6 inches high, in others 18 inches; this vessel of the sample experimented on was compared, on a white surface, with a precisely similar vessel of the same water, which had been previously freed from peaty colouring matter by mixing with it a large enough quantity of clay. By so treating any peaty water it was found that the peaty colouring matter could be completely removed, provided only sufficient clay were added.

Specimen A.—This is a fine cream-coloured clay from the foot wall of the gossan (iron ore) of the Ballymurtagh North sulphur lode, of which it forms the "selvage." Scattered through it is a small quantity of fragments of iron pyrites and milk quartz; with water it yields a clear solution, having an acid reaction, and containing a small percentage of ferrous sulphate and sulphate of alumina.

Insoluble in hydrochloric acid,	92·51 per cent.
Ferric oxide,	2·35 per cent.
Alumina,	2·43 per cent.

It was found to be a most efficient decolouriser of peaty waters.

When added to peaty water, the greater portion settled down almost immediately, but the very fine particles remained in suspension for a considerable time; when these had subsided, if sufficient clay had been used, the water was very clear; the top layer of the sediment being brown, as if the colouring matter had been carried down in it.

If an insufficient quantity of this clay were added to the water, several different stages were to be noted.

A very small quantity of clay altered the colour from a brown to a brown-green, and on adding a little more clay the colour altered to an olive-green. When more clay was added, but not sufficient to clear the water, a peculiar turbidity or cloudiness formed, which remained persistent, and did not appear to decrease on filtering. When this turbidity was removed by adding more clay, the water was freed from peaty colouring matter.

With the specimen of peaty water used in these experiments it was found that working with 1000 cc. of water not very darkly coloured, 1 gramme of clay brought on the brown-green stage; 1·5 grammes of clay the olive-green; 2·5 grammes produced a persistent turbidity; and that 4 grammes removed the cloudiness and the peaty colouring.

In order to determine what the active ingredient in this clay might be, some of it was digested in hydrochloric acid; the insoluble portion after being well washed was found to have very little perceptible action on the peaty water.

A strong aqueous solution of the clay was prepared (10 grammes of clay to 300 cc. of distilled water); this solution with a small quantity of the suspended particles was found to be capable of freeing the water from peaty colouring. After filtering the clay solution, it was found that the filtrate possessed the same property.

From these two experiments it is evident that it was someti dissolved out of the clay that acted on the peaty matter, and that insoluble portion had very little to do with it.

As on examining the clay solution it was found that it conta ferrous sulphate, a solution of ferrous sulphate was prepared; an this a few drops caused a peculiar turbidity to form, then a brown cipitate settled to the bottom, and the water was found to be from peaty colouring matter.

Sulphuric acid, hydrochloric acid, and nitric acid were also fo to precipitate the peaty colouring matter to some extent.

Specimen B.—A disintegrated light yellow red steatitic sl occurring in a dyke-like mass in the townland of Ballykillagee

It yields with water a turbid yellowish liquid, which clear standing, the suspended particles subsiding; the solution is neutr test paper, and none of the clay appears to be dissolved in it.

Insoluble in hydrochloric acid,	78·28	per cent.
Ferric oxide,	8·12	,,
Alumina,	7·96	,,
Manganese,	trace.	

This specimen also cleared peaty waters of their colouring ma though not so well as the last. When sufficient clay was adde entirely clear the water (25 grammes in 1000 cc.), the top laye the sediment, which was formed of the fine particles that had rema longest in suspension, was more deeply coloured than the rest.

When an insufficient quantity of clay was added to the p water, the changes were similar to those taking place with the specimen, viz., an alteration of the brown colour to a deep ol green; after which a cloudiness or turbidity appeared, but it appeared when sufficient clay had been added.

On digesting about 5·5 grammes of this clay with water, filte and evaporating the filtrate to dryness, only a very minute inorg residue is left, showing that there is very little soluble matter in clay.

Specimen H.—A bluish clay occurring in a cliff on the Bally gappoge brook. During floods a considerable portion is washed i the stream, and it probably assists in the decolourising of the water this brook, as mentioned in the field notes, p. 450, *supra*.

Digested with hydrochloric acid, it gives—

Insoluble portion,	81·79	per cent.
Ferric oxide,	6·72	,,
Alumina,	6·47	,,

When mixed with peaty water it seems capable of removing brown tint, but incapable of removing the greenish tinge; the wat however, remains slightly turbid.

When mixed with clear and colourless water it forms a very dirty turbid solution; after some time this clears considerably, but the liquid always retains a peculiar turbidity, which is very like the turbidity produced in a peaty water when an insufficiency of the clearing agent has been added. It was found that the turbidity could be removed by adding a small quantity of the next specimen to be described.

This blue clay seems to have been originally a red clay, very similar to that next mentioned (specimen *I*); its present condition being due to percolating peaty waters. This is inferred from the following observations:—1st. A similar blue clay overlies specimen *I*, as seen in the banks along the Mucklagh brook, the passage from one to the other being gradual; red stones and patches of red clay are seen occurring in this overlying clay. 2nd. The residues left by both specimens, after digesting in hydrochloric acid, are alike. 3rd. The percentage of insoluble matter in specimen *H* is greater than in specimen *I*, the more soluble portions, iron and alumina, having been probably removed by percolating waters.

Specimen I.—A brick red clay from one of the tributaries of the Mucklagh brook, where it occurs under a blue clay like the last specimen, a gradual passage from one to the other being distinctly visible. It yields an insoluble residue similar to the last, but the percentage of soluble matter is greater.

Insoluble in hydrochloric acid,	72·41 per cent.
Ferric oxide,	9·70 ,,
Alumina,	9·41 ,,

It yields with water a perfectly clear solution when the fine particles have subsided; which, however, is not for some considerable time.

This specimen acts as a very efficient decolouriser of peaty waters. When mixed with a peaty water the fine particles remaining in suspension give the liquid a brick-red colour; when they subside the peaty water is found to be quite decolourised, if sufficient (about 20 grammes to 1000 cc.) has been added.

With an insufficiency of clay the usual changes are observed.

Specimen K.—A whitish sandy clay, from the banks of the Carawaystick brook, where it occurs in an ancient moraine above the falls; it was some of this specimen that was mixed with the waters of this brook, as mentioned in the field notes, p. 451, *supra*.

Insoluble in hydrochloric acid,	93·91 per cent.
Ferric oxide,	1·60 ,,
Alumina,	2·17 ,,

This specimen, even in large quantities, produces very little alteration in peaty water; when added, very little remains in suspension for any length of time.

With a colourless water it yields a clear solution.

Specimen N.—A growan, or disintegrating granite, from Aughavannagh, Co. Wicklow. This rock occurs extensively in this district, underlying the peat. Deep channels are cut in it by the streams, which are not as peaty as might be expected, considering that they drain extensive bogs. In this growan are large veins of massive quartz and feldspar, which more or less resist disintegration.

The growan appears composed of quartz, and feldspar (the latter passing into kaolin, or china clay), with black and white mica.

Insoluble in hydrochloric acid,	86·68 per cent.
Ferric oxide,	3·80 ,,
Alumina,	6·24 ,,

This specimen at first seems to have very little effect on peaty waters, but, after remaining in the water some time, a layer of less darkly-coloured water was observed next to the clay. By repeatedly shaking up the clay and water, at long intervals, a marked reduction of peaty tint was observed in the water.

Some of the feldspar, mentioned as occurring in large veins through this specimen, after being pulverised, was found to act very similarly; a reduction of peaty tint only taking place after some time, and after being repeatedly shaken up. This feldspar contains only a very small quantity of iron, is very hard, and little altered.

In both the above cases, the top of the sediment at the bottom of the peaty water, after standing some time, becomes coated with a brownish substance.

With respect to the ingredients of these clays that are the active agents in decolourising the peaty water, it was found by experiment that a pure quartzose sand, even when in very large quantities, had no perceptible effect on the colouring of the water.

Pure gelatinous silica had likewise no effect.

The portion of a clay that is insoluble in hydrochloric acid was found to have at first no action on peaty water; but after repeatedly shaking the two up together it was found that the depth of colour was slightly reduced.

It was also found that freshly precipitated aluminic hydrate, ferric hydrate, and manganese oxy-hydrate precipitated the colouring matter rapidly and efficiently; of these the alumina is by far the most active; next the iron, the manganese being considerably less efficient.

The dry oxides of these metals were not found to be nearly so rapid in their action; in the case of ferric oxide and manganese dioxide it was only after being shaken up repeatedly that any decrease in the tint could be noticed; when left at rest for a considerable time, the layer of water next the oxide became decolourised; this extended gradually upwards, the surface of the oxide being coated with a brownish substance. This clearing of the bottom layer, and its gradual extension upwards, was most marked when a little potassic bisulphate was

placed at the bottom of a vessel containing peaty water. There is a marked analogy between this layer of clear water at the bottom of the vessels, and that mentioned by Professor Hartley, as occurring at the bottom of some of the Scotch lakes.

Magnesia was not found to affect the peaty colouring; pure carbonate of lime has only a very slight effect on the peaty colouring; pounded up chalk and limestone were found to reduce the tint slightly.

A hard water has only a very slight effect on the peaty colouring; but, on precipitating the carbonate of lime in the mixed waters, either by boiling or by adding to it lime-water, a large quantity of the peaty colouring is removed.

Lime-water added to a peaty water precipitates the peaty colouring.

By mixing some fresh hydrate of alumina and water together, filtering the solution, and adding some of the filtered liquid to some peaty water, the colouring matter was precipitated. By similarly treating hydrates of iron and manganese no precipitation of peaty matter was obtained.

In the field it was remarked that during frost, or when there was considerable snow in the drainage area of the river, the waters did not run nearly so peaty as at ordinary times, and often ran quite colourless, and mountain streams which at other times were deeply tinted were under these circumstances perfectly clear. Therefore some peaty water was frozen in tall cylinders, and it was found that although the peaty colouring matter was not precipitated, yet the behaviour was interesting, as the colouring appeared to resist freezing.

In such water, when the freezing took place gradually from above downwards, a layer of deeply coloured peaty water collected at the bottom, but the water resulting from the thawing of the small cylinder of ice was quite free from peaty colouring. When the freezing took place from the sides, a central core of darkly coloured peaty water collected. When the solidification took place rapidly, the darkly-coloured peaty water appeared enclosed in small patches through the block of ice, as though squeezed out of the freezing water, and concentrated in these patches which did not seem to freeze.

On freezing a cylinder of peaty water gradually from above downwards, then taking out the block of ice, leaving the layer of deeply coloured water at the bottom of the cylinder, refilling with peaty water and again freezing, and repeating this several times, a very small quantity of brown sediment settled down to the bottom.

Boiling peaty water gently for some time does not precipitate the peaty colouring matter; before a boiling temperature is reached, bubbles of gas escape from the liquid.

The discolouration which results from boiling peat for some time with distilled water can be almost entirely removed by filtering; but by adding a little ammonia to the water before warming, a large quantity of colouring matter becomes dissolved, giving the water a very dark colour. This colour is removed neither by filtering nor by boiling the water for a considerable time.

Conclusions from the preceding observations.

From the preceding observations in the field and in the laboratory it may fairly be inferred that—

Peaty colouring matter seems not to be removed by direct oxidation; this appears specially from the Carawaystick brook, where exceptional facilities occur for oxidation, and no peaty tributaries enter along that portion of the stream where it is lashed into foam down a height of about 700 feet.

Oxidation may play a certain part in precipitating peaty colouring matter, in so far that a ferrous salt, on becoming oxidised, carries down with it the peaty colouring matter; this appears to be an important factor in the decolourising of peaty streams; waters that are charged with ferrous carbonate flowing into them have the iron precipitated, the peaty colouring going down with it.

Ferrous sulphate also acts as an efficient decolouriser, but its occurrence must be comparatively rare; however, in the Ovoca river it plays an important part, and it is the most active agent in the clay specimen *A*; in the other specimens experimented upon it is the combined oxides of iron and aluminum, with manganese to a less extent, that appear to be the active ingredients: what their action on the peaty colouring matter may be has not been determined, but in ordinary peaty water there seem to be at least two distinct colouring substances; the one gives to the water a brown tint, which is comparatively easily removed, the other, only to be remarked when the brown has disappeared, gives it a greenish hue, which it is difficult to get rid of.

The peaty colouring is precipitated to a greater or less extent by either hydrochloric, nitric or sulphuric acids, more especially the last; it has also been found, as far as the experiments have gone, that salts having acid reactions act similarly, and some organic acids to a less extent.

When these observations were commenced, it was not anticipated that frost or dry weather would have had much effect upon the peaty colouring of streams. Why such is the case seems somewhat difficult to explain, especially as the experiments in the laboratory seem to prove that the peaty colouring is not precipitated by freezing.

After a long continuance of dry weather the waters in the streams and rivers are derived not from surface drainage but from springs, *i.e.* underground drainage, where the waters have been stored in the pores of the rock, and slowly percolating through the joints and crevices: any peaty matter these waters might have contained after percolating the overlying peat would probably be precipitated by the clayey matter contained in the joints of the rock. At the same time, any little drainage there might be from the peat probably collects in the holes that are always to be found; here the colouring becomes deepened, partly by evaporation of the water, but principally by dissolving out colouring matter from the surrounding peat. This may account for the reduction of tint observed after long continued dry weather.

In frosty weather the case is similar; the surface of the bogs is frozen, preventing the percolation of waters, and the water supply is often derived from melting snows; in one case it was observed that though a quantity of peaty water had collected behind a snowdrift, yet the water flowing from the other side of the drift was quite colourless.

In wet weather the principal supply of water is derived from the surface and superficial accumulations; that which flows from bogs and peaty ground is more or less tinted, as rain falling on these lands displaces the water contained in the reservoirs of the bogs, *i.e.* the pores of the peat and the surface holes such as "bog-holes," "turf-holes," and mountain loughs: as these waters contain a large amount of dissolved peaty matter, they flow into the streams deeply tinted.

At the commencement of dry weather the reservoirs in connexion with the rivers, such as lakes and pools, contain peaty waters, and it is not until these have been altogether displaced by clear water from springs, &c., that the streams flowing therefrom run colourless. The larger, therefore, a river and its reservoirs are, the longer it takes to become perfectly colourless.

Of the Shannon above Limerick, after the late long continued drought (March and April, 1881), there having been very little rain, and no floods for weeks, Captain King writes—"we have had no floods for a long time, and the river is in its purest state, even its usual boggy appearance has taken flight."

LXVII. — Report on an Investigation of the Character and Chemical Constitution of the Fibre of the Flax Plant. By F. Hodges, Fellow Inst. C.F.C.S. (Berlin), Zürich. With Plates XIV. and XV.

[Read, May 9, 1881.]

Kirwan, so early as 1789, laid the results of some experiments which he had made with the alkaline substances used in bleaching, before the Members of the Royal Irish Academy, prefacing his Report with the statement "that, however well the Irish bleachers might excel in that art, when well provided with the instruments they employ, they were but little acquainted with the general agency of the instruments themselves and their respective powers, or even with the most advantageous and economical method of employing them;" and Kolb in his elaborate Report to the Members of the Industrial Society of Mulhausen, 79 years later (1868), gave it as his opinion that the art of bleaching was no further advanced, so far as chemistry is concerned, than at the time of the introduction of chlorine by Berthollet. With the statement of Kirwan, few who know anything of Irish bleachers even now will be inclined to disagree; but with that of Kolb it is somewhat different, as it cannot be forgotten that on many occasions, long and laborious investigations into the constitution of textile fabrics, and the nature of the various chemicals employed as bleaching agents, have been made by eminent chemists; and if practical men have failed to turn to advantage the results obtained from these investigations—which results have been published from time to time—the chemists who undertook the work should at least be acquitted of the charge of being idle in the interests of bleachers.

Kolb, in the Report above mentioned, published the results of many experiments, which, if they had been carried out with Irish flax, instead of with Russian yarn spun from dew retted flax, would not only have possessed scientific interest, but have been of practical value to the Irish bleacher. It has, therefore, been considered advisable to repeat part of his investigation, with Irish flax, as well as to endeavour if possible to add to the very scanty information which we have of the nature of the wax and other bodies which exist in flax. We owe to Sir Robert Kane the first attempt to direct scientific attention to the composition of the stem of the flax plant. In a Report drawn up by Professor Hodges, at the request of the chemical section of the British Association of Science, and communicated to the Meeting held in Belfast, the agricultural and technical history of the plant was fully discussed, and the results of an extensive series of investigations on its composition given. This Report was the first in which an analysis of the proximate composition of the stem was published, and

t was followed, at subsequent Meetings, by Reports, by the same hemist, on the gases evolved in the steeping process; on the compoition of the steep-water; and on the composition of dressed flax. In his preliminary Report of a series of investigations on which I have een for some time engaged, I have endeavoured to extend our knowedge of the nature of some of the organic constituents of the plant, nd also of the effect of certain agents on the fibre. Flax as sold to he spinner consists, as is well known, of long and fine filaments, eparated from the stem of the plant usually in this country by a rocess called "retting," in which a decomposition of some of the ementing materials which hold together the structures of the plant is ffected, so that the textile filaments can be completely detached from he non-elastic and worthless portion of the stem, by the mechanical neans afterwards employed. The cells which serve technical purposes n the flax plant are those which exist in the bast tissue; these cells, f which the fundamental material is cellulose, are accompanied with arious incrusting and intercellular matters, which easily undergo olution or decomposition by chemical means—sulphate of aniline, as suggested by Wiesner, affords a test of exceeding delicacy for these incrusting matters, by the production of a yellow colour. The bast cells, as shown by the microscope, consist of long thick-walled cells in which the lumen has almost entirely disappeared. Iodine and sulphuric acid render the bast cells blue, while sulphate of aniline on the unbleached fibre shows the presence of some adhering and incrusting matter, by the production of a vivid golden-yellow colour; in the perfectly purified and bleached fibre this re-agent usually causes no change of colour, unless some of the incrusting matters have not been removed. The short cells and vessels which are situated on the inner side of the bast bundles of the plant are not rendered blue by the action of iodine and sulphuric acid. A series of of longitudinal and transverse sections of the structures which compose the stem of the plant, made in the laboratory of Professor Hodges, and carefully delineated by Mr. Tuffen West, whose abilities in drawing microscopic objects is so well known, affords probably the most perfect representation of their histological character which has hitherto been made, and also serves to show the effect of re-agents and the arrangement and mode of union of the cells. The action of nitric acid as shown in Plate XIV., fig. 1, is instructive as exhibiting the spiral striation of the thickening layers; while that of sulphuric acid and iodine on the section of an isolated cell, as exhibited in Plate XV., fig. 1, displays the concentric layers. In Plate B, fig. 2, the position of the groups of the bast fibres in the stem of the plant is well shown: fig. 3 shows the cuticle with stoma and remains of chlorophyll. A more full description of these Plates will be given in a subsequent communication.

Chemical Examination.

The flax fibre used in this investigation was pure Irish milled flax, of medium quality.

Estimation of loss of weight on drying.

7·6805 grms. flax fibre after drying at 100° C. for 12 hours weighed 6·796 grms., loss of weight 0·8845 grms. = 11·5 per cent. 5·07625 grms. of yarn manufactured from the same flax, after drying 12 hours at 100° C., weighed 4·5800; loss of weight 0·49625 grms. = 9·7 per cent.

After the retting of the flax, the gummy matters which were originally, says Kolb, uniformly spread over the fibre, disappear, and are replaced by numerous brilliant scales of a resinous appearance, equally distributed in the substance of the fibre, and in a manner adhering by their roughness to the filaments. These scales have a light amber hue, and are deepened in colour by alkalies, in which they can be entirely dissolved. By the mechanical process of hackling, large quantities of scaly matters are removed from the fibre. This substance, the nature of which is so little known, has been very differently named by many chemists; Berthollet calls it yellow colouring matter; Kirwan considered it a resin, differing from the true resins by its insolubility in the essential oils; M. Rouget de Lisle thought that it was, in combination with two others, of the nature of gummy extractive matter; Grimshaw ascribed the colour of raw flax and cotton to the presence of iron. In pursuance of the course of investigation here undertaken, it was considered proper to begin by studying the character of the bodies extracted from the flax by ether and alcohol, which was done in the following manner:—In order to obtain a sufficient amount of the bodies soluble in ether, the extraction was effected on a large scale in an apparatus which will be seen, by the accompanying sketch, to consist of a 4-litre bottle, with a tubule at the bottom, fused in an inclined position for better running off, which held about 400 grms. flax each time. The tube B carries the ether vapour from the flask underneath into the extraction bottle, and thence into a cooler, where it is condensed. The tube C carries the ether charged with wax and colouring matters back into the flask. Though all the most approved plans proposed for ether and alcohol extraction were tried, none were found so effective as the one here described, which during three days extracted 1·5 kg. flax with 4 litres of ether. The ethereal solution gradually turned light-green, and finally rather dark. On the cooling of the concentrated solution, a substance separated in white mammillary or flocculent masses. The hot extract was

and the ether distilled off. There remained behind a green-ss consisting of wax and essential oil. The latter was dis-ff, and, on being submitted to fractional distillation, it proved largely contaminated with alcohol from the ether. The oil which had a yellow colour, boiled at 85–100° C., and had remely disagreeable acrid smell. Though very large quan-f flax were at different times extracted, the quantity of this al oil which was obtained was too small to prepare a product stant boiling point for analysis. Though other workers on ve mentioned the existence of this oil, none of them have ever its boiling point, nor indeed separated it from the other mat-tracted with it. I hope, before the conclusion of this investi-to succeed in obtaining a sufficient quantity to enable me to tudy its character. In order to purify the white-coloured sub-it was dissolved repeatedly in hot alcohol, filtered while hot h a hot water funnel, and precipitated by cooling. By this it could be separated almost entirely from chlorophyll, of which was a very large quantity, and from a brown resinous substance ifficult to dissolve, which deposited at the bottom of the vessel, lidified on cooling; of this substance there were traces to be seen fter ten repetitions of this operation. By long continued wash-th cold ether, and drawing off with a pipette, at last a loose was obtained, showing a very slight greenish-yellow colour. over sulphuric acid, it melted at 78° C., already at 74° C. it was ly liquefied. The solidification took place at 72° C. This proves t was still a mixture of several substances, an opinion which irmed by the results of saponification with melting potash.

o combustions of the wax (melted and dried at 100° C.) yielded—

I.—*Substance employed*, 0·2090 grm.

CO_2	0·6060
H_2O	0·2483

C, 79·07 per cent., H, 13·19 per cent.

II.—*Substance employed*, 0·1685 grm.

CO_2	0·4940
H_2O	0·2042

C, 79·95 per cent., H, 13·46 per cent.

e following possible ethers correspond to the percentages quoted them:—

		C.	H.	
erotic ceryl ether, $C_{27}H_{53}OO(C_{27}H_{55})$,	requires	82·24	13·71	per cent.
almitic melissyl ether, $C_{16}H_{31}OO(C_{30}H_{61})$,	,,	81·65	13·60	,,
almitic ceryl ether, $C_{16}H_{31}OO(C_{27}H_{55})$,	,,	81·39	13·51	,,
almitic ceryl ether, $C_{16}H_{31}OO(C_{16}H_{33})$,	,,	80·00	13·33	,,

From which it can be seen that the last formula very nearly agrees with the results of the combustion.

Saponification.

Though this part of my work is far from being completed, owing to numerous difficulties which have presented themselves, it will, I believe, yield rich results. The method by which I proceeded was as follows:—Pure potash was fused in a silver dish, and about 6 grammes dry wax put in, in small portions. A soapy smell arose at once. The brown sticky soap was from time to time taken off with an iron spatula and put in water. After the operation was finished, the whole was put in a large quantity of water, and boiled for some time, till all was dissolved into a milky liquid. Then barium chloride was added, and the liquid filtered off the insoluble baryta salt, and the equally insoluble wax alcohols, which were washed with water. The mixture was boiled with ordinary alcohol to dissolve the new wax alcohol, filtered while hot, and the operation repeated four times. The last traces of adhering wax alcohol were removed by washing the baryta salt on the funnel with hot spirits of wine. The united alcoholic filtrates were concentrated to a small volume, by which the wax alcohol separated out and was removed by filtration. Purified once more by dissolving in absolute alcohol and dried, it melted at 82° C., a temperature which is open to correction, and requires further investigation, to ascertain the perfect freedom of the body from other substances, but which, if found to be correct, agrees with the fusing point of ceryl alcohol, which Brodie gives at 79° C., and Duffy at 81° C.

Preparation and Examination of the Fatty Acid obtained as a Barium Salt.

The barium salt was boiled for some time with strong acetic acid, and the fatty acid, which separated, filtered off. It was a brown substance melting at about 82° C. It dissolved in hot alcohol, with yellow colour, leaving behind a blackish-brown glutinous mass which solidified on cooling. This proves the existence of, at least, two fatty acids in the wax, or it leads to the supposition that it is a mixture of several ethers. Only that part which dissolved in alcohol was further examined. After repeated purifications with hot alcohol, it was obtained as a lead salt, by precipitation with lead acetate from a hot alcoholic solution. In this it was found that even the portion soluble in alcohol must be a mixture of several fatty acids. Along with a white flocculent lead precipitate, there was formed a brown precipitate, also containing lead, melting at a boiling heat, and adhering to the sides of the glass vessel. The two precipitates could be separated by prolonged boiling and pouring off of the liquid. The flocculent lead salt, which was present in large quantity, was filtered off and washed with hot alcohol. Dried at 80° C., and decomposed by hot acetic acid,

it formed a waxy acid floating on the liquid, melting at 82° C. The quantity of this was not sufficient for a combustion, and I had to content myself with preparing the ethyl ether, by dissolving the acid in absolute alcohol, and passing through dry hydrochloric acid gas. The ether was precipitated on the cooling of the liquid in microscopically small needles, melting at 60–61° C., and solidifying in a crystalline form. Both the melting point of the free acid and that of the ethyl ether agree very nearly with the data for cerotylic acid. Cerotylic or cerotic acid, F. p. 81–82° C.; Cerotic ethyl ether, F. p. 60·3° (Brodie). If the elementary analyses agree, these data will make it probable that the acid is cerotylic acid.

Extraction with Ether and Alcohol.

20·8555 grammes dried flax were extracted with absolute ether for twenty-four hours, and weighed 20·0455 grammes: loss of weight 0·810 gramme = 3·88 per cent.

The extract freed from ether (white wax and green oil) weighed 0·8057 gramme, corresponding to 3·86 per cent. loss of weight. The 20·0455 grammes, after extracting with absolute alcohol for twenty-four hours, weighed 19·9455 grammes: loss = 0·1000 = 0·45 per cent. The alcoholic extract was of a deep brown colour, and after evaporation of the alcohol evolved a smell similar to over-ripe stawberries. Kolb, in his experiments, found 4·8 per cent. capable of being extracted with ether and alcohol; but he carried his investigation no further than to give it as his opinion that the matters extracted were composed of two bodies of different densities—a wax, and an odorous essence, the former probably complex, all of which had been long ago shown to be the case by Dr. Hodges, and is now confirmed by the above experiments.

Extraction with Caustic Soda Solution.

18·734 grammes flax, previously extracted with ether and alcohol, and dried at 100° C.–112° C. for twelve hours, were boiled with caustic soda liquor, till no further loss of weight took place; remaining weight 13·406 grammes: loss 5·328 grammes = 28·4 per cent.

Preparation of Pectic Acid.

A large quantity of flax previously extracted with ether and alcohol was boiled for a short time, say one-half to one hour, with caustic soda solution, and a little sodium carbonate. The decanted liquor was decolourised as much as possible by animal charcoal, and filtered. The liquor was faintly brown. This liquor, according to Fremy, should contain pectic acid, as it is his idea that if either the ferment, to which he gave the name of pectase, or the free alkalies, or their carbonates, be allowed to act on a substance containing the organic body pectine, they can, the former at a temperature of 30° C.,

and the latter even in the cold, transform it, in the first instance, into pectosates and pectates, and finally, if their action be continued, into the remaining bodies of the series. The liquor gave, with an excess of hydrochloric acid, a brown gelatinous precipitate, which was washed on the filter with hot water for some time. During the washing the precipitate swelled a good deal, and much passed through the filter, so that gelatinous flakes deposited in the filtrate. In spite of washing, the precipitate still contained alkali (in 0·21925 grm. of dried precipitate 0·0025 grm. ashes). It dissolved in liquor ammonia with brown colour; the solution yielded a gelatinous precipitate with barium chloride. After drying, it resembled in appearance a woody brown mass, soluble in ammonium oxalate, but insoluble in absolute alcohol and ether.[1] On boiling with water it swelled up, and was gradually dissolved as presumably metapectic acid; which was shown by its reducing Fehling's solution, by turning brown with alkalies, and by yielding a gelatinous precipitate with silver nitrate. The solution gave an acid reaction with litmus. All the reactions here given agree with Fremy's statements about metapectic acid.

Extraction with Lime and Preparation of Calcium Metapectate.

A large quantity of raw flax was boiled for twelve hours with excess of milk of lime. The solution was filtered and freed from free calcium hydrate by a current of carbonic dioxide at a boiling heat. The filtered brown solution of calcium metapectate was concentrated and decolourised by animal charcoal. By evaporation in a platinum dish, a substance was obtained, at first gummy, then hardening, and still rather yellowish and rather hygroscopic. Two samples were powdered and dried for twelve hours at 100–110° C.

1·0632 grms. yielded on ignition ·2477 grms. $CaO = 23·22$ per cent.
·504 „ „ „ ·119 „ $CaO = 23·61$ „

The solution of calcium metapectate gave no precipitate with hydrochloric acid, nor with barium chloride and neutral lead acetate, but only with basic lead acetate. The precipitate was soluble in an excess of the precipitant. In order to ascertain whether Kolb was correct in his idea of the non-existence of a resinous saponification, many experiments were undertaken; and though they, like the rest of my work, are far from being completed, a few of them are here enumerated, the results of which, so far as they have gone, tend to confirm Kolb's conclusions.

[1] This is interesting, inasmuch as Messrs. Cross and Bevan, while working on a substance prepared in a somewhat similar manner from the jute fibre, state that they found it to be soluble in alcohol, and, therefore, not pectic acid; which is rather remarkable, as Schunk found a pectic compound in the cotton fibre; and Dr. Hodges and M. Kolb, in their researches on flax, describe the presence of pectic compounds.

Treatment of Flax Yarn in the Cold.

69·402 grms. flax were covered with 750 cc. water, and left standing for seven days. Loss of weight, ·14 per cent.

Treatment of Flax with Water at a Boiling Heat.

22 grms. flax were boiled for six hours with a-quarter litre water. The light-brown liquor gave a faintly acid reaction with litmus paper; with hydrochloric acid it was decolourised with the production of a faint white opalescence; with ammonium hydrate it turned strongly brown; with neutral lead acetate it yielded a brown flocculent precipitate; with basic lead acetate a much more abundant yellowish precipitate.

Treatment of Flax Fibre with Hot Solution of Sodium Carbonate.

10 grms. fibre were boiled with 50 cc. of a 1 per cent. solution of sodium carbonate for sixteen hours, with addition of about 150 cc. water. The liquor was poured off, the fibre was washed with water, and the total bulk of the liquid made up to 350 cc. A sample treated with hydrochloric acid showed no more effervescence, but gave a brown gelatinous precipitate, the liquid being decolourised.

Treatment of Flax Fibre with Hot Sodium Sulphide Solution.

13 grms. flax fibre were boiled for twelve hours, with a reflex cooler, with 1 cc. of a strong sodium sulphide solution and a great deal of water; sulphuretted hydrogen was given off in considerable quantity. After twelve hours a lead solution did not produce in the brown liquor a black, but a brown precipitate.

Imperfect and incomplete as is the above work, yet it will, I trust, be found to add some little to the knowledge hitherto possessed of the action of several chemicals on the flax fibre, and of the character and constitution of some of the constituents of the plant; and though all the results which were obtained in the series of investigations undertaken are not given in this Paper, as it has been considered advisable to hold them over, owing to the want of time for their completion, and the great difficulty experienced in preparing sufficient quantities of the materials to be examined, yet I venture to hope that those already given will be found to possess considerable scientific interest.

In conclusion, I take this opportunity of thanking my friend Professor Dr. Lunge, of the Technischchemisches Laboratorium Eidgenössisches Polytechnikum, Zürich, through whose kindness I was permitted to pursue these investigations in that laboratory, and for whose valuable suggestions I am greatly indebted. I have also to acknowledge the valuable assistance which was afforded me by my private assistant, Dr. Zimmermann, now assistant in the laboratory of the University of Zürich.

LXVIII.—The Instruments in the Old Observatory at Peking. By J. L. E. Dreyer, M. A.

[Read, June 13, 1881.]

When the missionaries of the Society of Jesus, in the seventeenth century, made their way to Peking, and startled the scientists of the Celestial Empire by their superior knowledge, they found in the eastern part of the city, on the rampart or wall surrounding it, an astronomical observatory furnished with several old instruments. Father Verbiest gained the confidence of the Emperor by repeatedly calculating beforehand the exact length of the shadow which a gnomon would throw at noon, and was authorised to have constructed six new large instruments. He has himself described these in a work with the following title:—"Astronomia Europæa sub imperatore Tartaro Sinico Cam Hy appellato, ex umbra in lucem revocata a R. P. Ferdinando Verbiest, Flandro Belga, e Societate Jesu, Academiæ astronomicæ in regia Pe Kinensi Præfecto" (Dillingæ, 1687, 4to).[1] The old instruments, which had to be removed to make room for his own, he seems to have paid no attention whatever to; at least he says nothing about them in his book, except (p. 47) that the Emperor gave him leave to construct new instruments—"Prioribus instrumentis Sinicis rudioris Minervæ, quæ jam a trecentis proxime annis speculam occupabant, inde amotis."

These despised instruments, as well as those erected by Father Verbiest, are still in existence. Some time ago I received from a friend residing in China, Mr. S. M. Russell, a series of photographs of these interesting scientific relics, and having had my attention drawn to them in this way, I thought that a short account of them might be read with some interest, particularly as there has not been much published about them hitherto.

The only plate in Verbiest's book represents the platform on which the six new instruments were mounted. It forms a square, with two small additions to the north-east corner, one of which is the head of the staircase leading up to the platform, while the other was occupied by a small house to which the observers could retire in bad weather. Next the staircase, on the north side of the platform, was a high mast, with a weathercock on it. Next to this was a sextant of six feet radius (*pedes geometrici*), evidently an imitation of Tycho Brahe's "Sextans bipartitus minoribus siderum distantiis inserviens,"[2] which it exactly resembles, with the exception that the arc is single. The arc

[1] This book seems to be rather scarce. Through the kindness of Father Perry, F.R.S., I have been able to examine a copy of it. Delambre gives an account of it in his *Histoire de l'Astronomie du Moyen Age*, p. 213, *et seq.*

[2] *Astronomiæ instauratæ Mechanica*, fol. D 3.

was divided to 15″,[3] and the observations were taken "per pinnacidia rimosa more Tychonico."[4] In the north-west corner was a quadrant (with the arc downwards), turning in azimuth round an axis which passed through the middle of the horizontal radius. In the middle of the west side of the platform was an azimuth circle, supported on four legs, and having in the middle a vertical axis, the upper end of which was joined by wires to the two ends of an alidade, which can be turned round the axis to any azimuth. In the south-west corner stood then a zodiacal armillary sphere, to which corresponded an equatoreal one in the south-east corner, while there was a revolving sidereal globe between them, six feet in diameter. Lastly, the middle of the east side of the platform was taken up by a low square tower, in the four corners of which four mandarins were posted, day and night, to observe the weather, meteors, &c., about which they prepared a daily report.

It would be needless to describe these instruments more in detail; they are true copies of the astronomical instruments devised and constructed by Tycho Brahe, and generally used long after his time. They were not furnished with telescopes. The photographs show with certainty that they have been moved about since they were mounted in 1673, as they do not now occupy the places they did then (as described above). Besides, there has been added a new instrument to the collection (but *when* I have not been able to find out), viz., another azimuthal quadrant. This instrument differs from all the others in not being profusely ornamented with dragons and serpents; on the contrary, it is in very pure European style. Possibly it was constructed some time during the eighteenth century, when the missionaries felt more at home, and less afraid of dispensing with what looked to them as heathen symbols.

Besides these instruments on the roof of the old observatory there are still in existence two others, equally large and imposing-looking, which are placed inside low brick enclosures in a kind of yard adjoining the observatory. These I had also (as I believe they have generally been) attributed to Verbiest, as they were not very different in their general appearance from his instruments. However, when I came across a Paper by Mr. A. Wylie—"The Mongol Astronomical Instruments in Peking"[5]—I found that they were in fact two of the old instruments which Verbiest removed from the observatory. When they were placed in their present positions appears to be unknown; Gaubil states that he was not permitted to get a look at them, and that they were kept in a closed room.[6] This agrees with what Father Le Compte says, who was in Peking about the year 1688, and who

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[3] Probably by means of transversals.
[4] *Astronomia Europæa*, p. 52.
[5] *Travaux de la 3e Session du Congrès International des Orientalistes*, Vol. ii.
[6] Souciet, *Observations Mathématiques*, &c., T. ii., p. 108.

saw them through a window "close set with iron bars."[7] They are now easily accessible.

According to Mr. Wylie, well-informed natives state that these instruments were made during the Yuen dynasty, and he quotes a Chinese description of Peking, in which the observatory and four large instruments (two of which, from the description, can be identified as the two still extant) are said to have been constructed in the year A.D. 1279. This date brings us back to one of the most interesting periods of Chinese history, as it was in 1279 that Koblai Khan, the great Mongol monarch, and grandson of Djengis Khan, finished the conquest of China, and moved his residence to the new city Taydo, now called Pe-King. Very different from his ancestors, Koblai was a monarch who favoured science and arts, and he supported and protected the astronomer Ko Show-King, who had first had the control of the waterways of the empire, but whom he, in 1276, appointed to examine the system of chronology then in use. Ko Show-King got the observatory built, and constructed a number of instruments, all of which are counted up in the *Yuen She*, or History of the Yuen (*i.e.*, Mongol) dynasty. The descriptions, as translated by Mr. Wylie, are in most cases very difficult to understand, except in the cases of the instruments *Keen e*, or equatoreal, and *Ling-lung e*, or armillæ—as these are the two standing at the present moment in the courtyard of the old observatory. About this identity there can be no doubt, as the above-mentioned description of Peking expressly states that the *Keen e* and the *Ling-lung e* were removed in 1673 from the platform, and stored away at the foot of the building. Gaubil (*l. c.*) also says that the instruments which in his time were kept "dans une salle fermée" were made by Ko Show-King.

It would only tire the reader if I were to reproduce the whole of the elaborate description of the Chinese writer, particularly as this is only intelligible when compared with a picture of the instruments. What I wish to call attention to in these pages is, that we have here two remarkable instances of how the Chinese people often came into possession of great inventions many centuries before the western nations enjoyed them. We find here in the thirteenth century the equatoreal armillæ of Tycho Brahe, and better still, an equatoreal instrument, like those "armillæ æquatoriæ maximæ" with which Tycho observed the comet of 1585, as also fixed stars and planets.[8]

It is well known that armillæ have been in use in China very early, and probably before the astronomers at Alexandria commenced using instruments with graduated circles. It is particularly stated by Father Gaubil that Sse-Ma-Tsien, about the year 100 B.C., mentions some *old* instruments, with circles of two feet five inches

[7] *Memoirs and Observations Topographical* (London, 1697), p. 65.
[8] *Astr. Inst. Mechanica*, fol. D 2.

diameter. It is added, that the motions of the stars were referred to the Equator, and that there was no instrument in use for observing the motion on the ecliptic. This would seem to indicate, that the Chinese astronomers, who in so many respects were behind the Greeks in their knowledge, had actually invented equatoreal armillæ (which were not in use in Europe before Tycho Brahe), and used them instead of the less convenient and unsymmetrical "armillæ zodiacales," invented by Hipparchus, and still used even by Walther and Regiomontanus.

But even if it be admitted that the description of these old instruments is much too vague to found on it a claim for the Chinese astronomers of the time before Christ as being the inventors of the equatoreal armillæ, at any rate it is now certain that Ko Show-King, the astronomer of Koblai Khan, constructed such armillæ three hundred years before Tycho Brahe. It has been suspected by the younger Sédillot[9] that Alhazen knew equatoreal armillæ; but even if this was really the case, it would probably be carrying conjecture too far to suppose the Mongol astronomer to have heard of this occidental invention.

The instruments of Ko Show-King were examined in one of the first years of the seventeenth century by the Jesuit Matteo Ricci (who died in China in 1610),[10] who speaks of them as being counterparts of some he had seen at Nanking, and described at some length. Mr. Wylie (*l. c.* p. 18) quotes the following part of this description from Colonel Yule's translation in *The Book of Ser Marco Polo* (Vol. ii.):—"A second instrument was a great sphere, not less in diameter than that measure of the outstretched arms which is commonly called a geometric pace. It had a horizon and poles; instead of circles, it was provided with certain double hoops, the void space between the pair serving the purpose of the circles of our spheres. All these were divided into 365 degrees and some odd minutes.[11] There was no globe to represent the earth in the centre, but there was a certain tube, bored like a gun-barrel, which could readily be turned about, and fixed to any azimuth, or any altitude, so as to observe any particular star through the tube, just as we do with our vane-sights."

This description evidently refers to an imitation of the equatoreal armillæ now in the courtyard of the Peking Observatory. The photograph shows in fact very distinctly that all the circles are double, separated by a narrow interval. Whether this interval was intended for the hollow tube to slide in, or whether the circles were only made double in order to strengthen the instrument, it is not easy to see. Perhaps both these objects were kept in view. The tube appears to have four longitudinal slits in it, 90° apart, and interrupted near the

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[9] *Prolégomènes des Tables Astronomiques d'Olough-Beg.* Paris, 1847, p. cxxxiv.

[10] Jöcher's *Gelehrten-Lexicon*, Vol. iii.

[11] It will be remembered that the Chinese divided the circle into $365\frac{1}{4}°$.

middle of the tube; but what they were intended, for I cannot make out.

The other instrument of Ko Show-King, the *Keen e*, which I have above likened to Tycho Brahe's armillæ maximæ, and which is by far the more interesting of the two, is described at great length in the *Yuen She*. It consists of a double declination circle, six feet in diameter, each circle two inches wide, and an inch in thickness. The interval between the two circles is one inch, and they are connected at four points 90° apart. "The degrees and minutes" are marked round the circumference (Father Matteo says, by prominent studs of iron, which could be felt in the dark). There is no polar axis, but two parallel stretchers, four inches on either side of the polar pivots, and joined in the middle by a transversal brace, in the middle of which is the pivot for the alhidade. The latter has pointed ends and two sights, with a round aperture in the middle, three-fifths of an inch in diameter, "with a fiducial line down the centre." The south-pole pivot is in the centre of a diurnal circle, also six feet in diameter, and divided into twenty-four hours. On this circle, which is let into the mounting of the instrument, slides an equator-circle of the same diameter, "divided into degrees and minutes, according to the twenty-eight constellations." The following particulars I copy *verbatim* from Mr. Wylie's translation:—"A hole is made through the centre of the north-pole pivot. At the bottom of this hole a transverse hole is drilled from side to side. A thread is passed up the centre, bent over, and brought out at the two transverse holes, and fastened at both sides. Three lengths of thread are passed through the hole, and fastened. At the upper and lower ends respectively threads are carried down to the two ends of the index bars (*i.e.* the alidade), and passed through a hole, being sunk into the under side of the index bar, along the centre line of which a groove is cut to receive the thread. It is then carried along the middle of the slit to the centre of the index bar, and through a hole in the middle part the thread is passed up from the lower side of the index bar, and fastened."

This thread or wire has probably disappeared from the instrument centuries ago.

Mr. Wylie's Paper contains two lithographs of the two instruments, but not seen from a good point of view, and consequently not showing all the details well. I trust the reader will have learned sufficient from the above descriptions to acknowledge the historical interest attached to these old instruments, which anticipated some of the ideas of the great Danish astronomer three centuries before his time.

LXIX.—PRELIMINARY REPORT ON SOUNDINGS TAKEN IN LOUGH GILL, SLIGO. By EDWARD T. HARDMAN, F. C. S., &c., H. M. Geological Survey.

[Read, June 13, 1881.]

A GRANT of fifteen pounds having been voted by the Royal Irish Academy towards carrying out the above object, the work was entered on during a part of last year (1880). Owing to various circumstances it was not commenced until somewhat late in the season, but advantage was taken of a continuance of favourable weather to obtain a great many soundings. These have been as yet confined to lines of sections along and across the lake, and in some of the principal bays and inlets of it, as well as depths ascertained around some of the various islands.

In this way a good deal of information has been obtained as to the form of the lake-bottom, and many interesting facts noted, which, when more fully followed up, will, it is expected, help considerably to elucidate the physical history of the lake.

It is proposed this year to continue these soundings, and to endeavour to obtain a series of depths along the shores at regular intervals from it.

The principal section runs right along the centre of the lake from end to end, beginning at the entrance of the River Garavogue, passing by Church Island, and continuing on to Shriff Bay. The depths along this line are considerable in some places; and one thing very noticeable is a tendency to very sudden differences of level in short distances. It is not uncommon to find within a distance of 400 feet a difference of depth of 30 feet or more.

The principal depths on this section are:—Between Cottage Island and Church Island, 65 feet; one mile from the latter island, 96·38 feet; a little further on eastward, 97·6 and 99 feet; then 105 and 116 feet, the last being the greatest depth yet found in the lake. This lies a little more than one mile from the east end of Church Island, and one mile and three-quarters from the east end of the lake. From this point to the end of the section at Shriff Bay the lake shallows again.

It should be noted that the depths given here are those actually taken. But as the water was at the time exceptionally low, and at least ten feet below its ordinary winter level, it would be necessary to add five feet for the average depths of the lake. The greatest depth would, therefore, be about 121 feet.

Another section was taken parallel to the last, and south of it, along the shore, from Aghamore Bay, through Goat Island, to Slish Wood. The depths along this line are moderate as far as Goat Island, where they suddenly increase. The northern shore of this island shelves down very rapidly, forming a deep cliff, which, at thirty yards from the shore, is 63 feet in depth. Further on the

feet, and half a mile east of the island, just opposite the Bunowen Bay, the sounding was 103·7 feet.

ions were run along the shores of Bunowen Bay, proving ren close to the shore to be very deep, in some places one ds only from the shore being from 35 to 47 feet.

were run from this bay to the south of Church Island, e considerable depths. A remarkable one is about sixty of the spit of land forming the southern point of the ..re there is a sudden drop of 84 feet in hard rock. all along the southern side there is very deep water, while the northern is very shallow.

er sections were run from Church Island to Leggamore Bay rell), and from this to Wolf land, near the Garavogue river. eatest depths in these were and 41 feet respectively.

Another section was obtained fr Toberconnel Bay, southwards, wards Rockwood, in the narrow part of the lake. The depths re are considerable—half a mile from the shore they reach 99 feet, a little further south 96 feet.

Besides the above, several isolated soundings were taken, but these possess at present no particular interest.

The season being then too advanced, the work was stopped. It will be continued this summer, and it is hoped that a full Report, with chart and sections, will be ready for presentation to the Academy during the next Winter Session.

Summary of Facts.—It would be premature as yet to enter into the geological aspects of the subject, but the following points may be noted:—

1°. The great and frequently-recurring irregularity of the bottom of the lake.

2°. The preponderance of depth (with few exceptions) on the south side, along which a great line of fault runs.

3°. That many of the deeps of the lake nearly coincide with the direction of known lines of faults in the shore rocks.

4°. That while the direction of the ice-flow, as indicated by the markings, in the district immediately around the lake is towards the N.W. or N.N.W. (that is, across it), the principal line of the lake is in an east and west direction.

5°. That the numerous small islands in the lake form subaqueous cliffs, which cannot be regarded as due to ice action, seeing that the "crag," or cliff, faces indifferently north, south, and east.

On the whole, therefore, the evidence at present seems to point to the origin of the lake as due to faults and subsidences in the first place, followed by chemical erosion of the limestone rocks along the lines of fault. That ice-action assisted in the details of the carving out to some extent there can be little doubt; but these matters will be fully entered into in a subsequent Report.

LXX.—REPORT ON THE ROCKS OF THE FINTONA AND CURLEW MOUNTAIN DISTRICTS. By G. H. KINAHAN, M.R.I.A., with Palæontological Remarks by W. H. BAILY, F.G.S. (With Plates XVI. and XVII.)

[Read, April 12, 1880.]

INTRODUCTION.

THE committee commenced operations in the neighbourhood of Pomeroy, and worked south-westwards to Lisbellaw, Drumshambo, Boyle, and Ballaghaderreen; while, for comparison, a traverse was made of the rocks in the Croaghmoyle, Toormakeady, Clew Bay, and Killary Bay districts.

As the fossils are an important element in the inquiry, on account of the occurrence of an assemblage of English Cambro-Silurian forms at certain places in the Irish Silurians, a list of those recorded from different areas is given in a tabular form, whereby those common to the different localities can be seen at a glance.

The report is divided into three parts:—*First.* A discussion of the Pomeroy and Lisbellaw fossiliferous rocks. *Second.* A Table of the Cambro-Silurian fossils found at Pomeroy and Lisbellaw, with those found in the different Irish Silurian tracts. *Third.* A discussion of the Silurian rocks, commonly called "Lower Old Red Sandstone," of Tyrone, Fermanagh, and the Curlew Mountains, with their relations to the Silurians of S.W. Mayo and N.W. Galway.

PART I.—(*In Abstract.*)

FOSSILIFEROUS ROCKS IN THE NEIGHBOURHOOD OF POMEROY.

Near Pomeroy are three distinct groups of rocks (neglecting the Carboniferous), namely—

3.	Red, purple, and greenish sandstones, conglomerates, and sandy shales, with interstratified masses of eurite (basic felstone), tuff, breccia, and, in places, green shales and limestone.	"LOWER OLD RED SANDSTONE" (Silurian).
2.	Green, grey, and bluish shales, slates, and grits; a few of the latter being quartzose and conglomeritic, while some of the shales are calciferous, and many of them fossiliferous.	POMEROY SERIES.
1.	Metamorphic sedimentary and eruptive rocks, with intrusions of granite, &c.	ARENIG GROUP.

the overlying ones of the "Lower Old Red Sandstone" type, and therefore to be confirmatory of the *primâ facie* presumption afforded by their fossils that the rocks of the Pomeroy series are of Cambro-Silurian age.

Lisbellaw Fossiliferous Rocks.

Two groups occur to the northward of Lisbellaw, the later lying unconformably on the older.

2.	Red sandstone and sandy shales, with some green beds. At Lisbellaw there are massive conglomerates with inliers of green shales. The massive conglomerates appear to be very local, as they do not occur to the north-eastward or westward.	"Lower Old Red Sandstone" (Silurian).
1.	Grey to dark blue shales, slates, and grits, with, in some places, green grits; some beds fossiliferous. They are occasionally metamorphosed in part as if by paroptetic action.	Cambro-Silurian.

The rocks of group 1 occupy only a small area, in which there are few exposures; they are fossiliferous near the hamlet called the Slate Quarry. From the rocks seen and a knowledge of other Irish Cambro-Silurians it is suggested that they are probably on a somewhat lower geological horizon than the rocks of the Pomeroy series. From a letter received from Mr. W. Staunton, it would appear that this authority, judging from the contained graptolites, considers the rocks of the Pomeroy series to be the equivalent of the Lower Llandovery, or the uppermost rocks of Cambro-Silurian age.

alities mentioned at the head of each column: to these ne others, the result of our visit to the districts we pro-stigate.

column (No. 1) is that of the Pomeroy district, Co. Tyrone, the beauty and variety of its fossils. The large number s are included in this list from that comparatively small . Amongst them the Trilobites, an extinct order of crus-r 27 species; Brachiopoda, 20 species; Mollusca-Conchifera, asteropoda, 10 species; Pteropoda, 5 species; and Cepha-cies: all these are Lower Silurian fossils of Caradoc-Bala majority are described and figured in Portlock's Report y of Londonderry, Tyrone, &c. The Trilobites include of which, as *Cybele rugosa*, *Remopleurides Colbii*, *Phacops P. truncato-caudatus*, *Trinucleus concentricus*, and *T. seti-* identical with those of Caradoc or Bala age from England others, such as *Harpes Dorani*, *H. Flanagani*, *Ampyx phus gigas*, *A. radiatus*, *A. rectifrons*, *Illænus Portlockii*, *s globiceps*, *Stygina latifrons*, and *Bronteus Hibernicus*, are rish species. The Brachiopoda are next in importance ites in respect to the number of forms; amongst them, *, Orthis fallax*, and *O. intercostata*, are the only species own to be exclusively Irish; the others, although some as *Discina oblongata*, *Orthis biforata*, *O. crispa*, *O. por-ema corrugatella*, *S. expansa*, *S. grandis*, are eminently of Irish strata, also occur in England and Wales, and in Scotland. Bivalve and univalve Molluscan shells nd Gasteropoda) are not unfrequent in these grey schists. former, Nucula-like shells, Ctenodonta, are plentiful, as pecies being enumerated; it is very possible, however, them may prove to be merely variations of form; Modio-bonychia are also frequent. Of the Gasteropoda, or uni-Euomphalus and Murchisonia are the most frequent. The

PART II.—BAILY'S LIST OF FOSSILS.

The Fossils of all the columns except No. 3 are of Caradoc-Bala forms, those of No. 3 being of Upper Llandovery types.

NAMES OF THE FOSSILS.	1. Pomeroy, Co. Tyrone.	2. Lisbellaw, Co. Fermanagh.	3. Boundary of townlands Cashel and Curmore, N.W. of Ballaghaderreen, N.E. of Co. Mayo.	4. Cliff above Lough Bellawaum, Co. Mayo.	5. S.E. flank of Mweelrea, Co. Mayo.	6. Uggool, Killary Harbour, Co. Mayo.	7. N.E. and S.W. of Toormakeady, Co. Galway.	8. Lough Mask, N.W. of Co. Galway.	9. Annascaul Beds, Dingle, Co. Kerry.
PROTOZOA.—*Spongida.*	—	—	—	—	—	—	—	—	—
? Cliona antiqua,	*	—	—	—	—	—	—	—	—
HYDROZOA.—*Graptolitidæ.*									
Diplograptus folium,	*	*	—	—	—	—	—	—	—
,, pristis,	*	*	—	—	—	—	—	—	—
Graptolithus sagittarius (Hisingeri)	—	*	—	—	—	—	—	—	—
,, Sedgwickii,	*	*	—	—	—	—	—	—	—
,, tenuis,	*	—	—	—	—	—	—	*	—
ACTINOZOA.—*Zoantharia.*									
Cyathophyllum (Petraia) elongatum,	*	—	*	—	—	—	—	—	—
Favosites fibrosus,	*	—	—	—	—	—	—	—	—
Halysites catenularius,	*	—	—	—	—	—	—	—	—
Heliolites interstinctus,	*	—	—	—	—	—	—	—	—
,, tubulatus,	—	—	—	—	—	*	—	—	—
ECHINODERMATA.									

Calymene Blumenbachii,	*	—	—	—	—	—	—	—	—
,, brevicapitata,	*	—	—	—	—	—	—	—	—
Cheirurus gelasinosus,	*	—	—	—	—	—	—	—	—
,, bimucronatus,	*	—	—	—	—	—	*	—	—
Cybele verrucosa,	*	—	—	—	—	—	*	—	—
Harpes Dorani,	*	—	—	—	—	—	—	—	—
,, Flanagani,	*	—	—	—	—	—	—	—	—
Illænus Bowmanni,	*	—	—	—	—	—	*	—	—
,, Portlockii,	*	—	—	—	—	—	—	—	—
Lichas Hibernicus,	*	—	—	—	—	—	—	—	—
,, laxatus,	*	—	—	—	—	—	—	—	—
Phacops Brongniarti,	*	—	—	—	—	—	—	—	—
,, caudatus,	—	—	—	—	—	—	*	—	—
,, truncato-caudatus,	*	—	—	—	—	—	—	—	—
Remopleurides Colbii,	*	—	—	—	—	—	—	—	—
Staurocephalus globiceps,	*	—	—	—	—	—	—	—	—
Stygina latifrons,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—
Trinucleus concentricus,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—
,, seticornis,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—
MOLLUSCA.—*Polyzoa.*									
Fenestella assimilis,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—
,, regularis,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—
,, undulata,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—
Ptilodictya dichotoma,	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	*
Brachiopoda.									
Atrypa imbricata,	*	—	—	—	—	—	—	—	—
,, marginalis,	*	—	—	—	—	—	—	—	—
Discina oblongata,	*	—	—	—	—	—	—	—	—
Leptæna scissa,	*	—	—	—	—	—	—	—	—
,, sericea,	*	—	—	*	*	*	*	—	—

NAMES OF THE FOSSILS.	1. Pomeroy, Co. Tyrone.	2. Lisbellaw, Co. Fermanagh.	3. Boundary of townlands Cashelduff and Cranmore, N.W. of Ballaghaderreen, N.E. of Co. Mayo.	4. Cliff above Lough Bellawaum, Co. Mayo.	5. S.E. flank of Mweelrea, Co. Mayo.	6. Uggool, Killary Harbour, Co. Mayo.	7. N.E. and S.W. of Toormakeady, Co. Galway.	8. Lough Mask, N.W. of Co. Galway.	9. Anascaul Beds, Dingle, Co. Kerry.
Pteropoda.									
Conularia elongata,	*	—	—	—	—	—	—	—	*
,, Sowerbyi,	*	—	—	*	—	—	—	—	—
Ecculiomphalus Bucklandi,	*	—	—	*	—	—	—	—	—
Theca reversa,	*	—	—	*	—	—	—	—	—
,, triangularis,	*	—	—	—	—	—	—	—	—
Cephalopoda.									
Cyrtoceras inæquiseptum,	*	—	—	—	—	—	—	—	—
Lituites (sp. cornu arietis, Portl.),	*	—	—	—	—	—	—	—	—
Poterioceras (Phragmoceras, Portl.), approximatum,	*	*	—	—	—	—	—	—	—
Orthoceras bilineatum,	*	—	—	—	—	—	—	—	—
,, breviconicum,	*	—	—	—	—	—	—	—	—
,, elongato cinctum,	*	*	—	—	—	—	—	—	—
,, filosum,	*	—	—	—	—	—	—	—	—
,, gracile (Portl.),	*	—	—	—	—	—	—	—	—
,, Ibex,	—	—	—	*	—	*	—	—	—
,, incertum,	*	—	—	—	—	—	—	—	—
,, per-annulatum,	*	—	—	—	—	—	—	—	—
,, Pomeroense,	*	—	—	—	—	—	—	—	—
,, subcostatum,	*	*	—	—	—	*	—	—	—

PART III.—(*Abstract.*)

Lithologically the Irish Silurians may be divided into *coarse accumulations* ("red arenaceous" type) and *fine accumulations* ("green and grey argillaceous" type), generally containing marine fossils; the former being the rocks commonly called "Lower Old Red Sandstone," and by Jukes, "Dingle or Glengariff Grits." This division, however, is no indication of relative age; for although the rocks of the first type are more often above the others, this is not always the case. On account of the Silurian strata having been deposited in separate basins, the littoral rocks, usually coarse, must be on different horizons, as shown in the plate of vertical sections (Plate XVII.).

The age of the British rocks called "Lower Old Red Sandstone" has lately been prominently brought forward by Dr. Archibald Geikie, in his Paper "On the Old Red Sandstone of Western Europe;"[1] and as his conclusions intimately concern the Irish rocks, they are now mentioned.

Geikie considers the "Lower Old Red Sandstone" of Great Britain to be a part of the same sequence as the typical Silurians, and he suggests five "Basins of Deposition":—

1. Lake Orcadia Basin.
2. Lake Caledonia, or the Middle Scottish Basin.
3. Lake Cheviot Basin.
4. The Welsh Lake Basin.
5. Lake of Lorne Basin.

If these are extended into Ireland, the second might be called the *Ulster and Connaught Basin*, and the fourth the *South Munster Basin*. The last extends westward into Waterford, Cork, and Kerry; it is thus briefly mentioned on account of its having to be referred to again in the present inquiry.

The western extension of the Caledonian Basin is first met with in Ireland, near Cushendun, on the east coast of Antrim, in a small tract of conglomerate, apparently a portion of the shore beds; but westward and southward the associated rocks are covered up by Mesozoic and Cainozoic rocks; in addition to which, at Lough Neagh they must be shifted or "heaved" southward by the N. and S. faults of that valley.

In south-east Londonderry, in the neighbourhood of Draperstown and Moneymore, there are red arenaceous rocks of uncertain age, which probably may hereafter be found to be outlying portions of this basin; but further southward, in Tyrone and Fermanagh, the large tract (*Fintona district*) of "Lower Old Red Sandstone," appearing from under the Carboniferous rocks S.E. of Pomeroy and extending westward to the Carboniferous rocks of the Erne Valley, seems un-

[1] *Trans. Roy. Soc. Edin.*, vol. xxviii.

questionably to belong to it. These rocks, as previously mentioned, lie unconformably on the Arenig rocks to the north, and on the Cambro-Silurians at Pomeroy and Lisbellaw. To the eastward, near Pomeroy, and to the westward, in the Topped Mountain district, these rocks are usually of a red colour and very arenaceous; but S.E. of Six-mile-Cross, where they appear to be best developed, there are, below, red arenaceous rocks with subordinate limestones and shales; above, there are green sandstone and shales, with a few limestones; while higher up there seem to be red arenaceous rocks. This, as will hereafter appear, is very similar to the section in the Ballaghaderreen district, Co. Mayo.

Further westward the rocks of this basin were again shifted or "heaved" southward by the faults of the Upper Lough Erne and parallel valleys, they appearing from under the Carboniferous S.E. of Lough Allen, near Drumshambo (Co. Leitrim). They are cut off on the westward by a down-throw to the west; but they shortly again appear east of Lough Key and in the Curlew Mountain district, the rise of ground from Lough Key, past Lough Gara, to the country N.W. of Ballaghaderreen (Counties Roscommon, Sligo, and N.E. Mayo). In the Curlew Mountains the base of these rocks is not exposed; but to the westward, between Ballaghaderreen, it is so, they resting unconformably on metamorphic rocks, either of Cambro-Silurian or Cambrian age, as mentioned in the Paper "On some supposed Cambrian Rocks in the Co. Tyrone and N.E. Mayo."

The mass of the rocks of the Curlew Mountain district belongs to the red arenaceous or "Lower Old Red Sandstone" type, except perhaps in the low country N. W. of Ballaghaderreen, where below and above they are of this type, but between they are of the "argillaceous" type, as more fully mentioned hereafter. All these rocks are evidently detached portions of the basin, other portions of which are found further south-westward, in the neighbourhood of Clew Bay, as in the Croagh Moyle, Mulrany, Clare Island, and Louisburgh districts. The rocks in these places, for the most part, are of the red arenaceous type; although in Clare Island and near Louisburgh there are greater or less thicknesses of red argillaceous rocks. All these rocks from Ballaghaderreen westward lie unconformably on metamorphic rocks, which are either Cambro-Silurian, or passage rocks into the Cambrian ("Arenig group," Upper Cambrian).

Immediately south and south-east of Louisburgh, at Creggaunbaun, and thereabouts, the Silurian rocks are, for the most part, metamorphosed, those that are unaltered belonging to the "argillaceous" type. This is remarkable, because to the south thereof, in the Mweelrea district, the rocks are principally of the red arenaceous type. The Mweelrea district is a portion of the large Silurian area that extends from Loughs Mask and Corrib, on the east, to the Atlantic, on the west, in which the rocks of both types are intermingled. This area occupies portions of S.W. Mayo and N.W. Galway.

In the counties of Cork and Kerry are the rocks belonging to the western extension of Geikie's "Welsh lake basin." Their base is said

ɔt to be exposed in the counties of Cork or Kerry[1]; but in the Com-eragh Mountains, Co. Waterford, there are conglomerates and other ɛks which the late Mr. John Kelly believed to be of similar age to ose of Toormakeady; and if this classification is correct, they must of Silurian age. To us it seems highly probable that they are the toral accumulations of the Cork rocks. These Commeragh rocks rest nconformably on Cambro-Silurians.

After this sketch of the Irish Silurians, including under that name e rocks called "Lower Old Red Sandstone," there are more de-iled illustrations of the rocks of the Fintona, the Curlew Mountain, d the other, districts.

In the *Fintona district* the general section in a S.S.W. line, from e rocks of the "Pomeroy series" to the flanks of the Altmore hills, ves rocks in the following order:—

Aghafad and Lurgylea Section.

4. Flaggy eurite.
3. Space without any rock exposure.
2. Purplish sandstones, flags, and sandy shales.
1. Greenish and purplish sandstones, flags, and sandy shales.

The eurites (No. 4) resemble compact basic purple felstones, but ey are in general full of divisional planes like stratification, which e rarely two feet apart, and usually less than one foot, while in aces they are so close together as to give the rock the aspect of a ale; but in the quarry lately opened at the Dungannon Water-orks, in the Altmore river valley, there is a massive eurite, which ems to be at or near one of the centres of eruption.

In the Aghafad and Lurgylea section the rocks east of, or below, e eurite (No. 4) cannot be seen; this space (No. 3) is probably occu-ied by rocks let down by faults and having a reversed dip, because a ile and a half to the E.S.E., in Glenbeg, eurites and tuffs occur dip-ing to the N.E. and E.S.E., apparently in the following order:—

Glenbeg Section (Pl. XVI., fig. 3).

6. Yellow tuff.
5. Green, purple, and prismoid eurite (only the weathered outcrop seen).
4. Yellow steatitic tuff.
3. Green and purple tuff.
2. Flaggy eurite.
1. Sandstone.

[1] Mr. M'Henry appears to be of the opinion that some of the rocks in the . Kerry classed as Silurian ought more properly to be classed as Cambro-ilurian, they being the equivalents of the rocks of the "Pomeroy series."

cks dip away from Altmore; but the eurite (No. 2) is representation of the lower eurite in the Altmore hills, n is somewhat similar to that to the westward, as seen at gh's Sentry-box (Pl. XVI., fig. 4).

Shane Barnagh's Sentry-box Section.

shaly, purplish to greenish, tuffs and tuffose rocks.
-, purple eurite.
4. 1 tuff; only the weathered outcrop visible.
3. ed eurite; beds rarely a foot thick.
2. Conglomerate; only the weathered outcrop seen.
1. Slaty eurite or tuff.

To the S.E., near the Back, good flags are raised in a portion of No. 3, while to the sou eof, nearer the bridge, the rocks belonging to No. 5 are so ver that, if found elsewhere, they would probably be classed as ord shales.

The best and most con tions are in the country southward of Six-mile-Cross. ever, are unsatisfactory, on account of the numerous faul cks seem to lie in the following order:—

Section S.E. of Six-mile-Cross.

6. Conglomerates and other arenaceous rocks.
5. Green sandstones and shales, with limestones and calcareous beds.
4. Red arenaceous rocks, with a few green beds and subordinate limestones.
3. Fault of the Glashagh (now Dungannon and Omagh Railway valley).
2. Thick eurite under a limestone (Aghnaglea).
1. Shales and limestone near the Camowen, probably belonging to the "Pomeroy series."

The shales and impure limestones (No. 1) probably belong to an outlying exposure of the "Pomeroy series," as previously suggested. The limestone in No. 2 was formerly extensively quarried, but the quarries are now planted by Lord Belmore.[1] The limestone and associated beds (No. 5) in Tandragee are very similar to those in the country N.W. of Ballaghaderreen, hereafter described, but in the Tandragee beds fossils have not been found as yet.

In the country southward of Six-mile-Cross, and in the neighbour-

[1] It is probable that it was from this locality that the fossils were sent to Griffith of which he said, "I got fossils from that country in rock very like the Toormakeady limestone, but never had time to visit the place myself." See Note in Press, page 500.

nd in part elvan, while south of them is the eurite mentioned
st section (No. 2), which seems to be on a lower geological
han the eurites, &c., of Altmore. Other roots occur in the
phic area north and north-west of Six-mile-Cross, and else-
At the mearing of the counties of Tyrone and Fermanagh a
shaly eurite was observed and boulders of limestone; but
not allow of that county being fully examined. Mela-
imilar to those that occur in the Mayo and Galway Silurians,
l among the rocks of the Fintona district.
e S.W. of this area special attention was directed to the con-
e of Lisbellaw, which at that village occurs in mass on the
Silurians. Half a mile to the W.N.W., however, in the rail-
ing, red sandstones are found close to the Cambro-Silurians,
the stream at the N.E. end of Lough Eyes, two miles from
r, the basal rocks are thin conglomerates, sandstones, and
Of the interesting blocks in the conglomerate, Mr. Thomas
, M.R.I.A., states that he "can find no rocks in N.W. Ireland
n, the nearest approach being some of the rocks of West Done-
t seems probable that as these inliers are granulite, hornstone,
, and other paroptetic rocks, similar to the "baked rocks" of
Silurian age in other places in Ireland, that they may be de-
m a now concealed mass of baked Cambro-Silurians, while
iated inliers of green shale may be the *debris* of the unal-
cks. A characteristic of the red arenaceous rocks of the
Mountain district, to the northward of Lisbellaw, is the pre-
innumerable inlying pieces of red, purple, and sometimes
ale. If we may judge from what goes on at the present day,
liers were small pieces of clay rolled over the sand by the
d afterwards flattened out; but where the source of supply
ted it is hard to conjecture.
e "Lower Old Red Sandstone" of the *Curlew Mountain district*
t eastward exposure is to the S. E. of Drumshambo, on the

town and Ballaghaderreen. The rocks, to a certain extent, belong to both types, as in the Fintona district, to the south-eastward of Six-mile-Cross; but at the same time, except that in a few green and calcareous beds, fossils of typical Silurian (marine) species have been found, all would have been included in the "Lower Old Red Sandstone." These rocks give the following sequence:—

Casheldluff and Ballaghaderreen Section.

5. Eurites, tuffs, and limestones, over	200 feet.
4. Purplish, red and greenish conglomeritic sandstones and sandy shales, about	5000 feet.
3. Green conglomeritic sandstones and shales, with a few thin impure limestones, and some subordinate red shales, about	4000 feet.
2. Red and purplish conglomerates, sandstone, and sandy shales, about	1500 feet.
	10,700 feet.

Unconformability.

1. Metamorphosed Cambro-Silurians or Cambrians.

The rocks in group 2 are exposed in a continuous section in the stream between Casheldluff and Cranmore, there being an unconformability between them and the underlying metamorphic rocks; they may possibly be a little thicker than represented, as a fault, with a downthrow to the southward, crosses the section, and may conceal some of the beds. The rocks in group 3 are not as well exposed, while the thicknesses of groups 4 and 5 had to be estimated. A little above the base of group 3, in the Casheldluff stream, are two fossiliferous bastard limestones; the fossils being principally of Upper Llandovery types, although a few are of Caradoc-Bala species (see Mr. Baily's list). To the west is Griffith's fossil locality, in the boundary of Glenmullynamaher and Uggool, where the fossils are principally of Wenlock types, although in beds below and above (Cloonnamna) this bastard limestone, they are of Upper Llandovery species; showing here also, as elsewhere in Ireland, the mixing together of species which in Wales are characterisic of distinct groups of rock.

The rocks in groups 2 and 4 are so nearly allied that they would not have been separated but for the intervening fossiliferous strata. Furthermore, the intervening rocks (group 3) are not so very unlike "Lower Old Red Sandstone," except as to colour, and the few calcareous and shale inliers; they being principally pebbly sandstones, with the inlying patches of shales so characteristic of the rocks of the Topped Mountain, Co. Fermanagh; they ought not, therefore, to be considered a separate group, but only a subordinate portion of a group.

A very similar change of colour takes place in the section of the Silurian rocks of Dingle, Co. Kerry (see Pl. XVI). The rocks of group 4 are best exposed in the neighbourhood of Lough Gara: but no satisfactory section of group 5 can be seen, although enough is exposed to suggest that they lie in the trough of a shallow synclinal curve, and that they are of greater thicknesses in some places: they seem to be associated with subordinate beds of impure limestone, because, although the latter rock was not found *in situ* except at Lough Key, yet elsewhere fragments occur associated with the eurites.

From the sections, it may be suggested that the rocks of the "Red arenaceous" type were either littoral accumulations, or depositions in shallow water; while the green beds seem to have been laid down in deeper water, which afterwards became shallow. In two places, viz., at Doon, on the west of Lough Key, and at Moy Gara, to the N. W. of Lough Gara, tracks, perhaps crustacean, very similar to those found at the Valencia Lighthouse, Co. Kerry, were observed.

In the Curlew Mountain district, as well as in the Fintona district, there are remarkable peculiarities in the feldspathic rocks. As mentioned already, those of Fintona have a thin-bedded structure, which looks like the stratification of sedimentary rocks or tuff, although they appear to be eruptive; here, however, their tuff nature is undeniable. To this subject attention has already been directed by Jukes and Foot (*Journ. Roy. Geol. Soc., Ireland*, vol. i., p. 247); but those observers appeared to be of the opinion that some of these rocks in the country between Loughs Gara and Key might be classed as normal eruptive rocks. In this Report it is pointed out that, to the westward, between Charlestown and Ballaghaderreen, there are roots of the eurites, elvans, and porphyries, occurring in the metamorphic rocks, while in the Lower Old Red Sandstone westward and northward of Ballaghaderreen there are bedded eurites and tuffs; but eastward in the Curlew Mountains the fragmentary and bedded characters are very decided, the euritoid rocks being breccias, grits, sandstones, and finely-laminated shales, all apparently having been re-arranged and deposited in water. From this it is suggested that the vent of eruption was to the westward; a characteristic of the vulcanicity being great discharges of tuff, or such-like mechanical products, which were subsequently re-arranged and deposited by water over a large area. This eruption must have been considerable, and for some time continuous, as otherwise the arenaceous rocks would have been interstratified with the tuffs, which does not seem to be the case. The isolated masses of these tuffose rocks on the Curlew Mountains are portions of the massive beds, separated and detached by breaks and denudation. The suggestion now offered to account for the phenomena just described accords with that proposed by Messrs. Du Noyer and Foot, in explanation of the similar phenomena to be observed in the rocks at Glenflesk, Co. Kerry.

At Doon, on the west of Lough Key, melaphyres similar to those of N. W. Galway occur associated with the euritoid rocks.

In continuation of the account of the "Lower Old Red Sandstone" basin on the westward, short descriptions of the Silurians of S. W. Mayo, N. W. Galway, and Kerry, appeared in the original Report. In the *Croagh Moyle district*, the "Lower Old Red Sandstone" consists principally of conglomerates, which lie unconformably on Cambro-Silurians or Cambrians (*Arenig rocks*). In places, under the conglomerates, are red sandy shales and sandstones; while very similar rocks occur in the country to the N. W. No eruptive rocks occur in them; but in places at their margin are limestones in the underlying rocks,[1] which are somewhat similar to the limestones, the associates of the eurites in the Fintona district, to the N. E., and in the Toormakeady district, a little to the southward.

Adjoining Clew Bay, near Mulrany, in Clare Island, and near Louisburgh, the rocks are somewhat similar to those of Croagh Moyle, except that red argillaceous rocks are more or less developed. In the north portion of the Louisburgh district these argillaceous rocks occur in mass; while in the south portion they are interstratified with the arenaceous. The Louisburgh beds constitute perhaps the latest division of the "Lower Old Red Sandstone" in Mayo, as they lie against metamorphic rocks (having been brought into that position apparently by a fault), an unaltered portion of which, at Creggaunbaun, contains fossils principally of Wenlock types. The relative positions of the rocks of Louisburgh, those of Creggaunbaun, and those further south in Mweelrea, are shown in the horizontal section, Plate XVI., fig. 5.

In the country to the south of the Croagh Moyle and Creggaunbaun rocks, and separated from these by Cambro-Silurian rocks, is the long narrow tract, extending from Lough Mask by the north of Killary Bay to the Atlantic, including the *Toormakeady, Formnamore,* and *Mweelrea districts.* Here, on the eastward (Toormakeady), there are massive conglomerates of the "Lower Old Red Sandstone" type, under which are fossiliferous limestones and shales. The conglomerates to the west of these in Formnamore merge into thin-bedded purple and green grits and shales; while still further westward, in Mweelrea, the rocks of the two types are more or less intermingled. That these different rocks are on one geological horizon seems proved, as below them are the continuous interbedded eurites and tuffs, which to the eastward are associated with the fossiliferous Toormakeady limestones and tuffs. The fossils of the latter are principally of Caradoc-Bala types, and similar fossils occur in green shales above the eurites to the westward in the Mweelrea district. This narrow area is remarkable; as there are not only rocks of the "Lower Old Red Sandstone" type and those of the "grey and green" series on the same geological horizon, but the fossils therein are principally those characteristic of the Welsh Caradoc-Bala rocks (Cambro-Silurian).

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[1] Symes has stated that these calcareous rocks may be of Carboniferous age, being due to infiltration.

This tract is bounded on the southward by a fault with a downthrow to the south; south of which is a second long narrow tract, extending from Loughs Mask and Corrib to the Atlantic, on the south of Killary Bay. In this area the rocks are, for the most part, of the "grey and green type"; but in places, as subordinate groups, sometimes coming in quite suddenly, and usually below, are rocks of the "Lower Old Red Sandstone" type; but the most conspicuous are the "Salrock slates," above, and probably at or near the same geological horizon as the "Louisburgh beds." A peculiarity connected with the "Salrock slates" is that, although the latest Silurian group in the county of Galway, the characteristic fossil is pronounced by Davidson to be of an English Upper Llandovery type. To the west of this tract, above the eurites, which are on the same geological horizon as those just mentioned as occurring at the base of the Mweelrea and Toormakeady rocks, there is a zone carrying Caradoc-Bala fossils; while below this zone the fossils are of species characteristic of the Upper Llandovery and Wenlock; while to the eastward, on this lower horizon, in the neighbourhood of Loughs Mask and Corrib, the fossils have been pronounced by Salter, Harkness, King and Baily, to be of types similar to the English Wenlock and Ludlow.

As the bedded eurites with their associated tuffs occur both north and south of the great fault that separates this tract from that to the north, it would appear that, although the rocks in the two areas were being accumulated at the same time, yet it was under very different circumstances, as to the depth of the sea and the animal life in the different portions of it. The changes in passing from north to south are very sudden, while those from west to east are more gradual: this is even more striking if we also take in the rocks farther northward. If a line be drawn from Croagh Moyle to Lough Corrib, the rocks at the northern end are the Croagh Moyle conglomerates, next are the Toormakeady conglomerates, with the fossiliferous limestones at their base (Caradoc-Bala fossils), and immediately south of them are rocks containing Wenlock and Ludlow fossils. Along a line from Mulrany, on the north side of Clew Bay, to the south side of the mouth of Killary Bay, the rocks exhibit even greater peculiarities, as shown in the following Table:—

Mulrany.—Arenaceous rocks principally.
Louisburgh (north).—Red argillaceous shales.
Louisburgh (south).—Red argillaceous and arenaceous rocks interstratified.
Creggaunbaun.—Green and grey fossiliferous rocks—(Wenlock type).
Mweelrea.—Red arenaceous and green argillaceous—the latter fossiliferous (Caradoc-Bala types).

GREAT EAST AND WEST FAULT.

Salrock.—Red slates (Upper Llandovery fossils).
Upper Lough Muck Beds.—Llandovery and Wenlock fossils).
Lower Lough Muck Beds.—(Caradoc-Bala fossils).
Gowlaun Beds.—(Llandovery and Wenlock fossils).

As to the Dingle promontory, Co. Kerry, although outside the province of the inquiry, it was pointed out that the rocks were both of the "grey and green" and of the "Lower Old Red Sandstone" types, and that in the *Anascaul beds* there are fossils of Caradoc-Bala species.[1] Of the other groups, the *Smerwick beds*, which are stratigraphically the oldest of the continuous sequence, are of "Lower Old Red Sandstone" type, and unfossiliferous; while above them are the grey and green fossiliferous *Ferriter's Cove series*, and, higher up, the *Croagh Marhin series*, which are a combination of both types; some beds being light-coloured and fossiliferous, the fossils being for the most part of Ludlow species, while over all come the typical reddish arenaceous Dingle beds.

A *résumé* in the original Report gave the relations between the different areas of the Silurian and underlying rocks.

AN EPITOME OF THE RESULTS OF THE INQUIRY.

Relations between the Silurian ("Lower Old Red Sandstone") *and the underlying and overlying Strata.*

Pomeroy.—In this immediate neighbourhood the rocks of the "Red arenaceous" type seem to lie unconformably on the rocks of the "Pomeroy series" (Cambro-Silurian), which they seem to overlap; north-westward, the rocks adjoining them are metamorphosed Cambrians; and southward they are overlain unconformably by Carboniferous sandstones.

Six-mile-Cross.—To the N. E. of this village, about a mile N. W. of Carrickmore, the Lower Old Red Sandstone lies against granite rocks of Silurian age; while about two miles S. W. of Carrickmore, in the valley of the Camowen river, there appears to be under them an outlying mass of rocks of the "Pomeroy series." Some of these "Lower Old Red Sandstones" are of the "Red arenaceous" type, in which there are subordinate limestones and greater or less thick-

[1] Jukes and Du Noyer have classed these beds as Silurians: but after more recent research we are informed by Mr. McHenry that he suspects that they ought to be classed as Cambro-Silurians; this was also Griffith's classification, but solely on fossil evidence.

of the rocks of the "grey and green" type. Some of the lime- are probably fossiliferous. In the country N. W. of Six-mile- the Silurians appear to lie directly on the metamorphosed ians.

bellaw.—Here rocks of the "Red arenaceous" type lie uncon- ly on Cambro-Silurians, while they are overlain unconformably boniferous rocks.

umshambo.—The Silurian rocks near this place are of both the arenaceous" and the "grey and green" types. They probably at Lisbellaw, on Cambro-Silurian, but their base is not exposed. re overlain unconformably by Carboniferous rocks.

rlew Mountains.—The rocks here appear to be some of the Silurians in N. E. Connaught, and to be on a higher geological than the rocks of Drumshambo; also than those to the rd, N. W. of Ballaghaderreen. They are principally of the arenaceous" type, although to the N. W. of Lough Key the top "grey and green" rocks is seen. They are overlain uncon- ly by the Carboniferous rocks.

llaghaderreen.—To the westward, and north-westward of Bal- erreen, rocks of the "Red arenaceous" type lie unconformably amorphosed rocks, which may be of either Cambrian or Cambro- n age. In the rocks of the "Red arenaceous" type is a mass and green rocks, containing fossils of Silurian and Caradoc- pes. The rocks of the "grey and green" type evidently con- only an inlier in the others, similar to those near Six-mile- except that in the last, fossils have not as yet been found. lurians are overlain unconformably by Carboniferous rocks.

agh Moyle.—Here the rocks all belong to the "Red arenaceous" being principally conglomerates, although in one place at ere is below them a considerable thickness of sandstone and hales. They lie unconformably on metamorphosed Cambrians bro-Silurians, while they are overlain unconformably by Carbo- s rocks.

rany.—Here are conglomerates, sandstones, and shales be- to the "Red arenaceous" type, lying unconformably on rphosed Cambro-Silurians, and overlain unconformably by iferous rocks.

re Island.—Although the rocks here belong to the "Red ous" series, there is in them a considerable thickness of red r shales. They lie unconformably on metamorphosed Cambro- ns.

isburgh.—Here, as in Clare Island, red slates and shales appear rocks of the "Red arenaceous" type, especially in the northern of the area, where they are of considerable thickness; while southern part they are interstratified with sandstone and con- tic rocks. The rocks of part of this area lie unconformably on rphosed Cambro-Silurians, while the rest are brought down by against metamorphosed Silurians.

Creggaunbaun.—In the greater part of this area the rocks are metamorphosed. Those that are unaltered are of the "grey and green" type, and yield fossils of Wenlock and Upper Llandovery types. They lie unconformably partly on metamorphosed and partly on unaltered Cambro-Silurians.

Mweelrea Mountains.—The rocks here are partly of the "Red arenaceous" type and partly of the "grey and green" type: the two types in places are intermingled. In some of the grey and green beds there are fossils principally of the Caradoc-Bala species. They lie unconformably on metamorphosed and unaltered Cambro-Silurians.

Formnamore Mountains.—These rocks, although on the same geological horizon as those of the Mweelrea Mountains, are, for the most part, of the "grey and green" type, but no fossils have been found in them. They lie unconformably on metamorphosed Cambro-Silurians, and are capped by Carboniferous rocks.

Toormakeady Mountains.—Here a second change takes place; the rocks, although a continuation of the last, being nearly altogether massive red conglomerates; but at their base are limestones and tuffs, carrying fossils of Caradoc-Bala types. They lie unconformably on metamorphosed and unaltered Cambro-Silurians; while, like the rocks of the Formnamore Mountains, the Carboniferous rocks lie unconformably on them.

Tract of Country between Cong, Lough Corrib, and the Culfin, on the Atlantic.—The rocks here are separated from those of Mweelrea, Formnamore, and Toormakeady, by a great nearly E. and W. fault, with a downthrow to the southwards. They are nearly altogether of the "grey and green" type, but with them are associated remarkable subordinate sets of beds of the "red arenaceous" type. The uppermost beds, "Salrock slates," belong to the latter, and have, as their characteristic fossil, one of an Upper Llandovery type; while lower down various types of fossils are intermingled—one zone carrying fossils of Caradoc-Bala species. These rocks lie unconformably on metamorphosed rocks of Cambro-Silurian and Cambrian ages, while they are covered unconformably by the Carboniferous rocks.

Dingle Promontory.—The rocks (*Anascaul beds*) that are supposed to be the oldest in this district contain Caradoc-Bala species. Jukes and Du Noyer classed them as Silurians, while Griffith and M'Henry would put them among the Cambro-Silurians. Of the rocks forming a continuous sequence, the lowest (*Smerwick beds*) and the highest (*Dingle beds*) are of the "red arenaceous" type; the rocks in the intermediate groups are of mixed types, the "grey and green" type predominating. The base of the rocks of the sequence is not seen; while on the Dingle beds the Carboniferous rocks lie unconformably.

Glengariff Grits.—These rocks are principally of the "red arenaceous" type; their base is not exposed; while on them the Carboniferous rocks rest conformably in the country to the southward (West

Cork), and unconformably in the country to the N. E. (south-east Kerry and north-east Cork).

Commeraghs (Waterford).—In these mountains are conglomerates very similar to those of Toormakeady and Croagh Moyle, which were supposed by Kelly to be of similar age. They are possibly the littoral accumulations of the Silurians of West Cork (Glengariff grits). They rest unconformably on the unaltered Cambro-Silurians, while they seem to be covered unconformably by rocks of Carboniferous age.

SILURIAN EURITES.

These rocks and their associates are characteristic of the "Lower Old Red Sandstone," not only of Ireland, but also of Scotland. The Irish rocks are not all on the same geological horizon. It may be possible that they are the results of two periods of active vulcanicity, and, for the present classification, it may be supposed such was the case, and that they belong to two different zones.

Upper Eurite Zone.

Fintona District.—Eurites, tuffs, and calcareous rocks, at Altmore and N.E. of Fintona. The eurites and limestones eastward of Six-mile-Cross seem to be older than, while the eurites near Ballygawley seem to be of the same age as, those eastward of Six-mile-Cross.

Curlew Mountain District.—Tuffs and calcareous rocks of the country between Loughs Key and Gara. Near Ballaghaderreen, eurites, tuffs, and limestone.

North-west Galway.—The bed of eurite in the "Salrock slates" of the hills south of Leenaun; limestones at Dernasliggaun and Rossroe; and the newer eurites in the Kilbride promontory (Lough Mask).

West Kerry.—Eurites and tuffs, Valencia Harbour.

East Kerry.—Eurites and tuffs of Glenflesk, Lough Gitane, and the Horse's Glen (Mangerton).

Lower Eurite Zone.

Croagh Moyle District.—The limestones at the base of the Silurians.

Toormakeady District.—Eurites, tuffs, and limestones, at the base of the conglomerates.

Formnamore.—Eurites at the base of the group.

Loughnafooey.—Eurites and limestone in the vicinity of Loughnafooey; oldest eurites and tuff of the Kilbride promontory (Lough Mask); eurites of Rinavore (Maum Valley).

Mweelrea District,—Eurites at the base of the Silurians.

Culfin.—Eurites of Benchoona and of the hills to the eastward.

Dingle Promontory.—Eurites and tuffs in the "Ferriter's Cove series."

NOTE ADDED IN THE PRESS.

From Glashagh, the valley adjoining Lord Belmore's quarry, Mr. Thomas Plunkett, M.R.I.A., has sent me a piece of a fossiliferous boulder of a greenish argillaceous rock. This rock is very similar to some of the rocks of the "Pomeroy series," and contains fossils common therein; but it is also similar to some of the green argillaceous rocks of Tanderagee. In these, however, no fossils have been found as yet. The principal fossil, *Leptæna serica*, is one of the characteristic fossils of the Toormakeady Silurians, and therefore it may possibly occur in the Tanderagee "grey and green beds." The boulder could scarcely have come from the Pomeroy area, as the driftage from that was towards the south; but, as I have already suggested, there may possibly be an outlying exposure of these rocks to the north of this place; while it is also possible that the "Glashagh fault" may bring up the rocks of the "Pomeroy series" under the drift of the valley.

EXPLANATION OF PLATES.

Plate XVI., Fig. 1.—Map of the Pomeroy area, showing the probable extent of the rocks of the "Pomeroy series" and some of the eruptive rocks of the Altmore district.

" Fig. 2.—Aghafad section, showing the probable unconformability between the rocks of the "Pomeroy series" and the "Lower Old Red Sandstone."

" Fig. 3.—Glenbeg section, showing the reversed position of the eurites and tuffs.

" Fig. 4.—Shane Barnagh's Sentry-box, section of the eurites, tuffs, and associated rocks.

" Fig. 5.—Sections showing the relations between the Silurian rocks of Louisburgh, Creggaunbaun, Mweelrea, Salrock, and Lough Muck.

Plate XVII.—Longitudinal section indicating the original position of the rocks in the Silurian basin between Clare Island, Co. Mayo, and Cushendun, Co. Antrim. The probable outline of the floor of the sea is indicated, while the faults that have since shifted it are left out.

" Sections showing the relations between the beds in the Mweelrea and Partry Mountains with those to the north in Croagh Moyle.

" Three series of vertical sections: one showing the sections at the principal points in the main longitudinal sections; another of the principal sections in the longitudinal section from Mweelrea to Croagh Moyle; and the third, the sections along the cross sections from Culfin to Louisburgh (fig. 5, Plate XVI.).

[illegible]), and [illegible]
[illegible] and [illegible]
Commerag[illegible] [illegible]
similar [illegible]
[illegible]

These [illegible]
[illegible]
for [illegible]
and [illegible]

[illegible]

Croagh [illegible]
Toorn[illegible]
Formna[illegible].—[illegible]
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[illegible]rec [illegible]
[illegible].—[illegible]
[illegible] *Promontory*.—[illegible]

bones in the tendons of the flexors, are observable on the plantar aspect of these two metacarpals.

Tendons.—Those of the long flexors are to be seen.

Muscles.—Interossei occupying the same positions as in the previous section. Four lumbricales are also present, situated near the tendons of the flexor longus digitorum.

Manus.—Sections passing through the distal extremity of the manus present a very close resemblance to those taken from the pes. The tendons of the perforating and perforated muscles lie in the same position in both.

A section taken through the first phalangeal joint shows the cartilages, which, by subsequent ossification, become sesamoid bones in the flexor tendons.

The most instructive section of the manus is one taken through the centre of the metacarpus. Such a section presents the following objects for observation :—

Bones.—There is no space left between the third and fourth metacarpals, but a small one between the second and third and first and second, and for the most between the fourth and fifth. The three central metacarpals are of a somewhat oval shape. The fifth is more nearly circular, while the first is of this shape ().

Tendons.—The slips attaching the extensor tendons to the bones are visible, as are also the tendons of the perforating and perforated flexors.

Muscles.—The following are observable :—Flexor brevis pollicis, flexor brevis minimi digiti. Three lumbricales. The normal interossei are present, but there is an extra interosseous muscle in the interspace between the second and third metacarpal bones. This also differs from the others in its situation, the normal muscles lying to the palmar aspect of the metacarpals, and the extra one between the two before mentioned. It is interesting, as pointing to a possible original symmetry of the interossei in point of numbers; but before laying any stress on this point, I am anxious to discover whether a similar arràngement obtains in other canine manus.

I hope soon to be in a position to lay before the Academy a more extended Report of my investigations on the human manus, which I am now carrying on.

Having lately obtained a large supply of materials, in the shape of human fœtus, I hope to be able to make a tolerably complete examination of them.

In conclusion, I desire to take this opportunity of thanking Dr. Macalister for materials and much kind assistance.

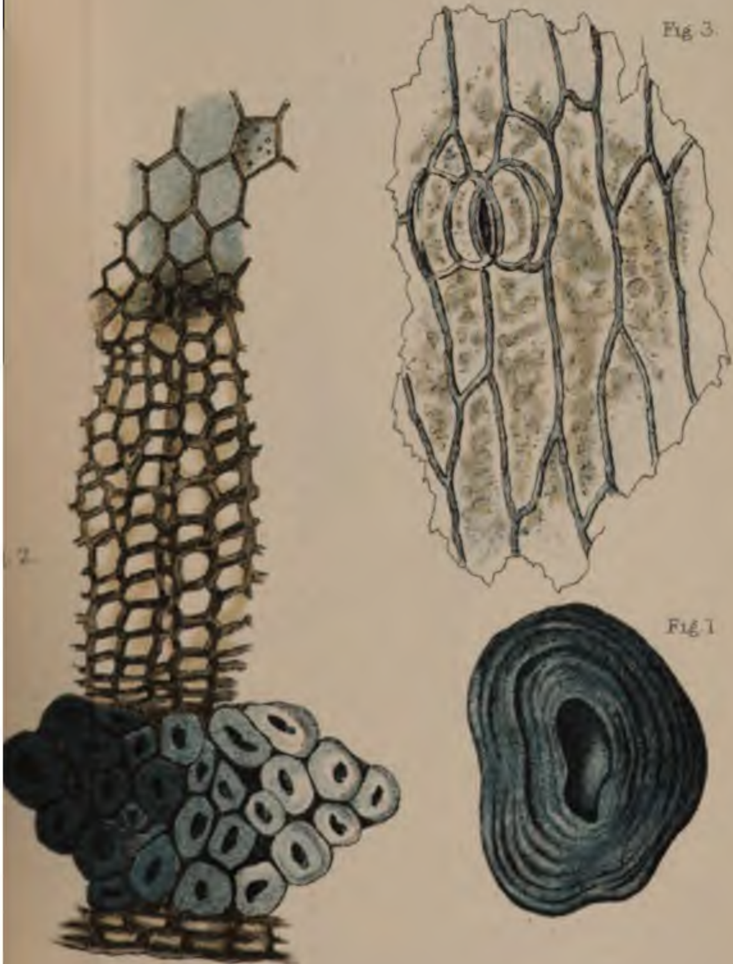


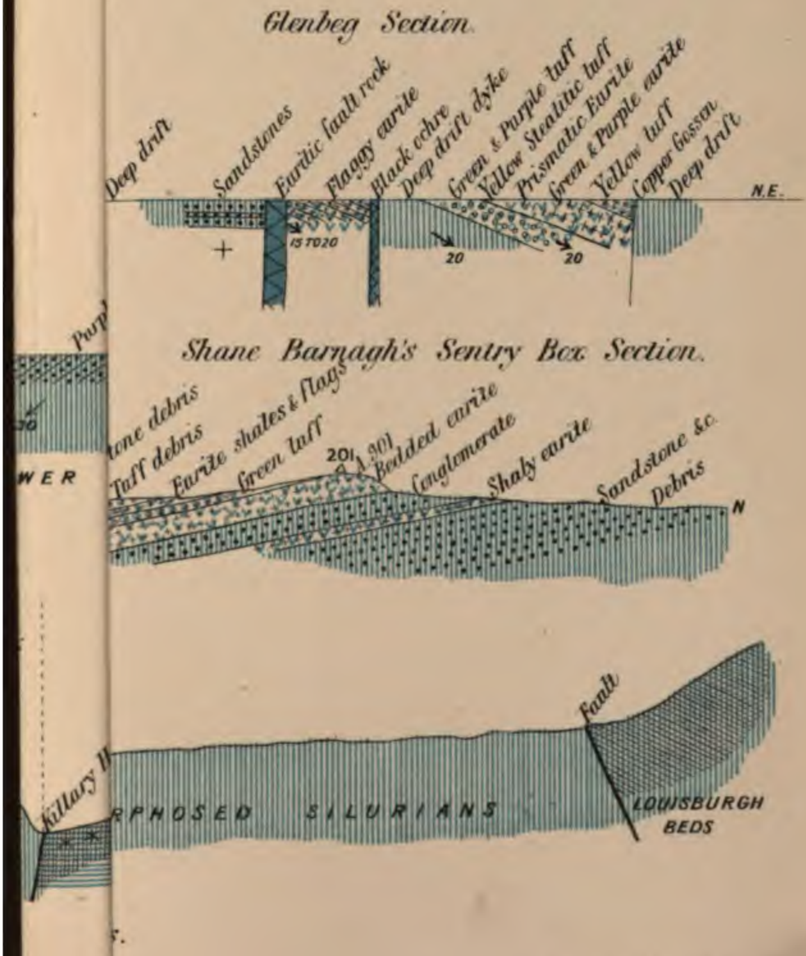
Fig 3.

Fig 1.

2.


Fig. 1

Plate XVI.



Forster & Co Lith, Dublin

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LXXII. — ON A RELATION TO BE ESTABLISHED BETWEEN COAST-LINE DIRECTIONS REPRESENTED BY GREAT CIRCLES ON THE GLOBE AND CERTAIN LOCALITIES IN EUROPE MARKED BY FREQUENCY OF EARTHQUAKES. By JOSEPH P. O'REILLY, C.E., Professor of Mining and Mineralogy, Royal College of Science, Dublin.

[Read, November 14, 1881.]

FOR the student of Geology no phenomena of Nature present a wider, more interesting, or more important field of study than Earthquakes. So sudden, so terrible in their effects, so difficult to observe, so mysterious in their causes (even in the present advanced state of knowledge), and therefore so insufficiently studied, every branch of science can find in them matter for observation and study second to none in importance. It might seem, therefore, that a complete, continuous, and systematic record of such events would be deemed indispensable for the progress of the natural sciences; and such a record we possess in Mallet's Report and Catalogue of Earthquakes up to 1850, published by the British Association, but for the subsequent years it is to be regretted that we have no continuous catalogue in English, such as those of Professors Perrey and Fuchs in France and Germany.

That this is really a want must be evident from the interest excited by the increasing frequency and intensity of earthquakes in Central Europe, by the manifest desire to collect more precise and extended information as regards their occurrence, and by the admitted insufficiency of the theoretical views in vogue as regards their causes.

The records of Professors Perrey and Fuchs, with difficulty accessible in Great Britain, are yet of the greatest value, and their examination suggests the possibility and the desirability of bringing into more intimate relationship earthquakes, as phenomena, which are apparently quite independent, and have up to the present been only brought into connexion from the point of view of contemporaneity.

Yet the dependency existing between volcanic action and earthquakes is fully admitted; moreover, there is recognised a well-established connexion between volcanoes and great lines of jointing, more especially sea coast-lines. It is therefore reasonable to assume that a similar connexion may be found to exist between these and earthquakes—that is to say, sea coast directions and lines of main jointing being recognised as the loci of volcanic actions, so evidently connected with earthquakes, should there not, consequently, exist some relation between these same directions, as representing lines of main jointing and localities markedly affected by earthquakes, far apart though they may be geographically?

In the present memoir I endeavour to establish such a connexion, parting from the Theory of Coast-lines Correlation, submitted to the British Association in 1878 (Dublin), and subsequently published by the Royal Irish Academy in its *Transactions* (November, 1879). In that

memoir[1] I endeavoured to show that the direction of coast-lines in general is mainly due to jointing; that this must be dependent on the mineralogical constitution of the rock or rocks in which it is developed; that this constitution, variable at surface, must change in depth; and in so far as we have any knowledge of it for great depths, may be presumed to be that of the trap-rocks or basalts; that these, when in great masses, frequently present a columnar structure, acquired by contraction; that the predominating angles of the prisms formed are, as observed at the Giant's Causeway, of 110°, 70°, 40°, and angles resulting from the combination of these. I further argued that secular contraction is admittedly going on in the crust and at the surface of the earth, but only locally, and therefore unequally; that there are being formed continuously in the earth's crust points of maximum tension; that when rupture and consequent local contraction take place, there are produced planes of rupture or joints, which necessarily divide off and limit a certain extent of the earth's crust, and give rise to polygonal forms at the surface of the globe; that these planes or joints being developed in massive rock, presumably of the nature of basalts, and of very great thickness and extent, give rise to polygonal or prismatic forms, presenting angles such as those observed in basalts; that by reason of the predominance of certain angles these must repeat themselves, and give rise to directions of planes of jointing which at intervals are similar; and consequently, that prolonging on the earth's surface a system of jointing along which contraction towards the centre has taken place, this system, marked by its direction, should reoccur at intervals, and show a connexion or correlation with other directions through the intermediary of the predominating angles already mentioned.

This theory was supported by examples, and subsequently by the determination and comparison of the systems of jointing observable about the Bay of Dublin, which I showed to have manifest relations with the directions of the neighbouring coast-lines, in accordance with the theory submitted.[2]

Such a theory, however, requires repeated and very direct proofs before it can claim acceptance. If well founded, it should admit of being pushed to its logical consequences, and such I take to be the connexion which I propose to establish between coast-line directions (or their correlated lines and parallels) and localities noted for their earthquakes.

As a matter of fact all earthquakes, whatever their origin, must bring into play the systems of fissuring and jointing which have existed in the locality, tending, however, to modify them and to increase their extent and number.

[1] "On the Prismatic Forms of a Group of Basalts, Giant's Causeway." (Roy. Irish Acad. *Transactions*, vol. xxvi., part 22, Nov. 1879.)

[2] "On the Directions of the Main Lines of Jointing observable in the Rocks about the Bay of Dublin, and their Relations with the adjacent Coast-lines." (Roy. Irish Acad. *Proceedings*, vol iii., ser. ii., No. 5, Dec. 1880.)

the connexion between vol-
the connexion between
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.s of jointing, there
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.s itself.
r a series of years be taken,
a map; if, furthermore, the
iori on the globe be also laid
my theory be well founded) be
.e earthquake localities and these
es.

: map of Europe, which I now submit
. by marking the earthquake localities
.llet, Perrey, and Fuchs down to 1880.
:alities mentioned, I was unable to distinguish
frequency of occurrence, except by hatching
shocks have extended, and rehatching or cross-
.ne reoccurrence of the earthquake under the same
single localities, however, a simple round or small
.dicates that they have been cited as having suffered at
:k.

.n map has been before prepared, and the present one must
.l rather as an essay than as a complete work. If intensity and
.ncy could be represented on such a map, very interesting rela-
would certainly be established thereby. If, moreover, such map-
ould be done on a globe, still more remarkable results might be
ed to follow.

. examination of the map shows that as the localities are multi-
so does their tendency to develop into certain lines become more
d; and considering, on the one hand, the meagreness and incom-
ess of these records down to the middle of the last century, or
ncement of the present, and on the other the shortness of historic
s regards the development of geognostical phenomena, the results
sted by the map must be considered as distinctly pointing to a
connexion between coast-line directions and certain earthquake
ts in Europe.

the localities lying in Europe and around the basin of the Medi-
ean, which have been and continue to be marked by frequent
olent earthquakes, the following are the principal:—

ly and Sicily.
.e Adriatic coast-lines.
eece and the adjacent islands.
.e triangular space bounded on the west by the Rhone, on the
east by the Mediterranean coast-line from Marseilles to Genoa
.e prolongation thereof from Genoa to Trieste, and on the north-
y a line extending from the Vosges to the neighbourhood of

ite. (This triangular space takes in Switzerland and part
)

Rhine district, extending from the confines of Bad
rland to Holland in a direction nearly north and sou
pr ting about one hundred miles in breadth from west to
The Saxony district, more circumscribed, but perfect
marked.

Various districts in France, particularly the line of the Py
Great Britain.
The west coast of Portugal.
The south-east coast of Spain.
Sweden and N

Outside Euro n connexion with the Medite
nd Black Seas :-

Asia Minor, st coast and Sea of Marmora.
The north co
The Syrian
The line of t uc

As explained in the n "On the Prismatic Forms of
of Basalts," I traced on the globe sixty-seven coast-line great
correlated by certain angular relations, and of these great cir
following traverse Europe and the adjacent continents :—

No.
2. East Cape Madagascar.
3. West coast of Read Sea.
4. East coast of Red Sea.
5. Coast of Syria.
7. West coast of Morocco.
12. Southern boundary of the tertiary formation of the States.
13. East coast of South America.
14. North coast of Africa.
15. West coast of Portugal.
16. East coast of England.
23. Caucasus great circle.
24. South-east coast of Africa (Sofala coast).
28. Axis of Sumatra.
32. North-east coast of Persian Gulf.
50. Promontory of New Ulster.
51. East coast of Sweden.
53. East coast of New Zealand.
52. West coast of Sweden.
66. South-west coast of Australia.

I have now to show in what relation these lines stand.

First, with the localities in Europe marked by earthquake action; and secondly, with similar localities outside Europe.

In discussing the first point I shall confine my observations to those lines which the method employed in recording the earthquakes on the map has brought out prominently and distinctly, leaving aside for the present the less well-marked lines and less clearly-defined districts.

The following may be pointed out as such well-marked lines:—

I.—*The Boundary Line of the Tertiary Formation of the Valley of the Po.*—This line meets the coast-line direction No. 13 (east coast of South America) at Novara, making with it an angle of 70°. It is very remarkable by reason of the frequency of earthquakes along its direction. On it are situated Pavia, Piacenza, Parma, Reggio, Modena, Bologna, Imola, Faenza, Forli, Rimini, Ancona—all frequently cited on account of their earthquakes, the shocks either having been noted in a single locality, or at several localities along the line.

Its prolongations north-west and south-east, within the limits of Europe and the coast of Syria, pass through many localities remarkable for the frequency and intensity of their earthquakes. Thus, on the north-west it traverses Mount St. Bernard, the Rhone at Tournus, the district about Tours, and cuts the coast-line of Finisterre at Landernau, an earthquake point. Towards the south-east it practically represents the axis of the Adriatic, cuts the Albanian coast at Durazzo, the Thessalian coast at Volo (both well known by reason of their frequent earthquakes), traverses the Sporades, cuts Rhodes at its northern point, and the Syrian coast about Ascalon, crossing the Dead Sea at its southern extremity.

The coast-line between Genoa and Massa may be considered as parallel to it, and roughly the coast-line between Pescara and Brindisi on the east side of Italy.

The coast-line from Ancona to Pescara may be considered as correlated with it by the angle 40°, as also the coast-line between the Gulf of Policastro and Gulf of Santa Euphemia.

II.—*Marseilles, Toulon, and Laybach Line.*—The coast-line direction and earthquake locus just considered meets at Parma the very remarkable line extending from Marseilles and Toulon to Laybach, over a distance of about 500 miles, well marked by repeated shocks, sometimes local only, at others having extended along the whole line. This line might in reality be considered as extending to Barcelona, in Spain, and as regards correlation may be taken as making an angle of 40° with the east coast of England direction (No. 56).

It might also be considered as parallel to the direction of the Murcia earthquake zone, which, parting from near Almeria, is drawn on the map at an angle of 70° with No. 6 (west coast of Africa).

To the west this Marseilles-Laybach line cuts the Spanish coast at Cadiz; to the east it passes through Hungary, running about thirty miles north of the Balaton Lake, and parallel to its axis. It passes at Pesth, runs parallel to and to the north of the earthquake line which extends from Kardzag to Szathmar Nemeths. It there meets the earthquake line which extends from Lemberg in Gallicia to Hermannstadt in Transylvania, making with it an angle of about 70°.

III.—*East Coast of Sardinia Line.*—At Parma the two last described directions are intersected by another, equally well marked—that is, the line represented by the east coast of Sardinia, drawn on the map at 80° with the north coast of Africa (No. 14), but which might also be considered as a parallel to the east coast of Sweden direction (No. 51).

This east coast of Sardinia direction passes through Elba, runs parallel to the Leghorn coast-line, passes at Parma, between which city and Leghorn simultaneous shocks of earthquakes have frequently occurred, follows the west side of the valley of the Adige, and touches in its extension the western side of the Saxony earthquake district.

IV.—*East Coast of Sweden Direction.*—This direction, nearly parallel to the last described, is much more distinctly marked in its characteristics as a line of earthquake action.

Its correlation with the great circle coast-line directions is 40° with No. 50 (Promontory of New Ulster).

That portion of it extending from Nordköping to Karlscrona is well marked by its rectilineal direction. Farther south it passes at Prague, Undine, Rimini, and mouth of the Tiber; traversing the Tyrrhenian Sea, it cuts the African coast at Cape Bon and at Sfax. As regards this portion of the line, it may be remarked that up to the present (23rd July, 1881) there had not been recorded (in the lists consulted) any earthquake as having taken place along this coast of Tunis, although theoretically the extensions of the coast-line directions already described would point out this country as one of earthquake action. Now, owing to the presence of scientific observers in this country, within the last month or so we receive intelligence of an earthquake or earthquakes having taken place in and about the Gulf of Gades; and, furthermore, notice of the fact that the constitution of the country is volcanic. I cite this fact to show how those lines may be interpreted as regards districts but little explored.

The section of this line between Rome and Rimini is one of the best-marked earthquake lines in Italy, while the section between Pola and Brück is also well defined as a direction by a series of points along which shocks have been continually occurring. Between Palermo and Naples a parallel to this coast-line direction seems to be marked out by earthquake movements, cited as having extended from one point to the other (April 16, 1817).

V.—*Bari Coast-line Direction.*

VI.—*Policastro-Nicastro Coast-line Direction.*—The southern or Calabrian part of Italy presents two coast-line directions, well marked by earthquake action, the one represented by the line extending from the Gulf of Manfredonia south-eastwards, the other by the Val de Diano and the coast-line on to Nicastro. This one is very strongly marked, and distinctly parallel to the great circle direction, south-east coast of Africa or Sofala coast (No. 24).

VII.—*East Coast of England Direction.*—A very remarkable coast-line direction is that representing the east coast of England. It is correlated with the great circle direction No. 12 (River St. Lawrence, or southern boundary of tertiary formation, United States), by the angle of 40°.

As shown on the map it runs parallel to the east coast of Iceland, traverses the Ferroe islands, parallel to the axis of the main island, runs along the east coast of Hoy island in the Orkneys, touches Scotland at Kinnaird's Head, runs parallel to the east coast of England from the Firth of Forth to the Wash; passes at Bruges, traverses the well-marked earthquake district which extends from the plateau of Langres by Geneva and Savoy to Nice; traverses Sardinia, cutting its coast-line at Cagliari; cuts the Tunisian coast, passes at Tunis, and enters Africa proper at Jerba island in the Gulf of Gades.

That portion which extends from the plateau of Langres to Nice only partially represents an earthquake line, although Geneva, Savoy, and Nice may be considered as constituting one; but the parallel to this coast-line represented as passing through the island of Elba presents a well-defined character. Thus parting from the Shetland islands, it traverses the Zuider Zee at Harderwick, and marks well in its extension the western boundary of the Rhine valley earthquake district. The central axis of this, which may be taken as extending from Gross Gerau to Stuttgard, is parallel to it. The continuation of that axis, from Stuttgard southwards to the vicinity of Parma, may also be taken as representing a line of earthquake action, though not so distinctly marked as the more northerly portion.

VIII.—*West Coast of Africa Coast-line Direction* (*No.* 6).—This coast-line direction enters Spain at the Cabo de Gata, passes near Madrid, cuts the Santander coast at Santillana, crosses the Bay of Biscay, and meets the Irish coast at Cork—one of the localities in Ireland, the best marked as regards frequency of occurrence of earthquakes. Its continuation northwards runs along the west coast of Iceland, and practically parallel to it. As an earthquake line it is not very remarkable over this extent, but there seems to be developed parallel to it a line of earthquake localities, extending from Tarbes by Bordeaux and Nantes on to the coast of Dorsetshire, through the Channel islands.

This line is very distinctly marked, and may be considered as the axis of a zone or band which would include the eastern portion of Spain, the western half of France, Great Britain and Ireland, the Faroe Islands, and Iceland.

IX.—*The Almeria or Murcia Earthquake District* may be considered as correlated with this line by the angle of 70°. It has a well-marked direction, and its extension eastwards represents the coast-lines of Iviza and Majorca, crosses the northern part of Corsica, touches Elba, and traverses Italy from Piombino by Sienna Arezzo and Urbino—points well marked by repeated earthquake movements.

X.—*South-east Coast of the Adriatic* (*Allesio to Aolona*).—This line, of no great extent, yet well marked as regards earthquake movements, is interesting from the fact that its parallel, lying between Bosnia-Serai and Ragusa, has been cited as a line along which simultaneous earthquake action has taken place (June 27, 1869). Now, this line may be considered as making with the coast-line, north-east of the Persian Gulf (No. 32) an angle of 80°, and produced defines correctly the line of the Danube between Waitzen and Essek, along which shocks have been cited as having occurred, parallel to which there is a very distinctly marked line of earthquake action represented by a series of points between Kesskemet and Petervasara in Hungary.

As regards the coast-lines, properly so called, certain of them are well marked by the frequency of earthquakes and succession of the points at which they have been noted. This is the case as regards the west coast of Portugal, the north coast of Africa, the Syrian coast, the Adriatic coasts, the western coast of Asia Minor, the north-east coast of the Black Sea, the southern coast of same between Samsun and Trebizonde. The northern or Cantabrian coast of Spain, so markedly rectilinear and so well defined by the great circle, No. 66 (south-west coast of Australia), is not cited as having presented remarkable earthquake movements; yet the few localities cited in this respect are upon this great circle. Taking into consideration only those more remarkable coast-line directions, their parallels, and certain lines correlated therewith, it may be advanced that they furnish sufficient evidence to justify the proposition, that between certain of these coast-line directions and localities in Europe markedly characterized by the frequency and intensity of their earthquakes, there exists a very distinct relation of direction, and that this relation would be much more distinct were our earthquake records more complete, and if they had extended over a greater period of time than that corresponding to our chronology, a period so comparatively short so far as geognostical factors are concerned.

Many minor proofs of parallelism and correlation might be pointed out, and may be easily gathered from the examination of a map.

Thus, examining the Rhine valley earthquake district, it may be observed that not only is it well defined on the west by the east coast of England direction, but that, moreover, the locality of relatively greatest intensity, which may be taken as corresponding to Gross Gerau, occurs at the intersection of the great circle direction, Axis of Sumatra (No. 28), with the parallel to the coast of England passing through Elba.

Furthermore, the great circle direction No. 56, Promontory of New Ulster, passes somewhat to the south thereof at Strasburg and Carlsruhe, and defines sufficiently the northern boundary of the Saxony central earthquake district. This district may, indeed, be defined as bounded on the north-west and south-east by this great circle, and a parallel thereto, and on the north-east and south-west by the great circle, east Cape of Madagascar (No. 2), and a parallel thereto. This great circle (No. 2), and those representing the east and west coasts of the Red Sea, are very characteristic in their intersections, and all pass through Iceland, and would suggest a possible connexion between the volcanic and earthquake activity of that island and localities situated on these great circle directions. Such connexion or simultaneity of action at points of a coast-line direction wide apart is demonstrated by the repeated occurrence of shocks at Græchen in Switzerland and Constantinople, on the same day and nearly same hour, both points being situated on a parallel to the north-east coast of the Persian Gulf (No. 32). It is evidently of extreme importance to follow out these relations, since, if established for points at great distances on great circle directions, every new relation thus established between phenomena apparently isolated and unconnected points towards a law, and would be of a nature to guide physicists as to the localities whereat seismographs may be most advantageously established for observation.

These considerations lead up to the examination of the second point which I proposed to consider, that is, the relations to be established between these coast-line directions considered as great circles and localities situated outside Europe, and noted for the frequency or intensity of their earthquakes. In order to do so in a summary manner I have detailed the points through which these great circles pass, printing in thick type the known earthquake localities, and in italics those known only on account of volcanic action.

No. 2.—EAST CAPE MADAGASCAR.

Antigonil Bay.	
Astone and Cosmoledo Islands.	
Abyssinia,	Near Gondar.
Nile,	At Syene, First Cataract, Mineah.
Mediterranean Coast,	Arabs Gulf.
Candia,	Near Cape Sidero.
Sporades.	
Eubœa Island,	(Twelve miles east of).
Killodromi Island.	

Salonica.	
Servia.	
Hungary, ...	Betwen **Essek** and Zombor, **Mohacs, Funf**chen, **Balaton Lake.**
Austria, ...	**Vienna.**
Bohemia, ...	**Prague, Eger, Erzgebirge Mountains.**
Saxony, ...	**Chemnitz, Leipzig, Dresden.**
North Germany, . .	**Elbe Mouths.**
Shetland Islands, . .	(Seventeen miles south of).
Faroe Islands.	
Iceland, ...	**Vatna, Jokull, and north-west point of.**
Greenland.	
Canada, ...	Hudson's Bay, Cape Churchill, Winnipeg Deer Lakes.
Oregon and California, .	Cape Conception.
Marquesas Island.	
Poumota or Low Archipelago.	
Sabrina Land.	
Kerquelan Land, . .	(Thirty-three miles south of).

No. 3.—WEST COAST OF RED SEA.

Africa, ...	Makdishu, Somali Coast, **Nile Mouths**, Damiet
Rhodes and west coast of Asia Minor, . . .	**Samos, Mytelene.**
Turkey, ...	Kara Su. R., **Sofia.**
Servia.	
Hungary, . . .	**Szegedin, Buda-Pesth, Kremnitz.**
Bohemia, ...	**Kœniggratz.**
Silesia, ...	Gorlitz.
Prussia, ...	**Berlin, Potsdam.**
Denmark, ...	**Ribe.**
Shetland Is., . . .	**Lerwick.**
Faroe Is.	
Iceland, ...	**Vatna Jokul,** and north-west point of.
Greenland.	
Canada, ...	Hudson's Bay, near Port Nelson; Winnipeg Lal
Utah, ...	**Salt Lake,** south-east point of.
Californian Coast, . .	Catalan Is.
Marquesas Is.	
Paumota Group.	
Adelie Land.	
Sabrina Land.	
Bourbon Is., . . .	(Twenty-three miles east of).

No. 4.—EAST COAST OF RED SEA.

Seychelle Is.	
Gulf of Aden, . . .	Berbera.
Arabia, ...	Mocha.
Red Sea, ...	*Farsan Is.*, Head of Acuba Gulf.
Cyprus, ...	Fifty miles west of C. Arnauti.
Asia Minor, . . .	South Coast, C. Kiledonia, **Sources of Menan** Twenty miles west of **Ushak.**
Sea of Marmora.	
Wallachia.	

ry, . . .	**Debrezin, Karchan.**
. . . .	**Breslau.**
ermany, . .	Landsberg.
k.	
ad Is., . . .	**North Unst.**
l, ...	Kressonaes, Glamn Jokul.
and.	
, ...	Hudson's Bay, North-west point Labrador, Winnipeg Lake.
nia, . . .	Course of River Colorado, Head of Gulf of California.
esas Is. and Society Is.	
Land.	
Land.	

No. 5.—COAST OF SYRIA.

Coast, . . .	**Gaza, Beyrout, Tripoli, Antioch, Iskanderoon.**
Minor, . . .	Near Sivas, **Unieh, Black Sea Coast.**
dia, . . .	Michelowski.
us, ...	Mount Papnii, near Ekaterinodar.
. . . .	Near Nyzni Novogorod, runs parallel to the course of the Volga between Tenatitin and Kaimishin.
beria, . . .	Head of Taimurski Bay.
ast Siberia, . .	Chaunskara Bay, C. Alyastorski.
an Is., . . .	Atcha Is.
ich Is., . . .	**Tani Is.**
Is., . . .	Tahiti Is.
. . . .	*South-west Coast*, St. Helen's Bay, cuts the Equator at 26° E. Long. near bend westward of Congo, *Nile* (2nd and 3rd cataracts), Egypt, Keneh, Peninsula of Sinai.

No. 7.—WEST COAST OF MOROCCO.

. . . . .	**Guadiana Mouths,** Albuera, Caceres, Palencia, Salamanca, Mts. of Europe, Santander Coast, Deva R. Valley.
, ...	**Loire R. Mouth, St. Malo, Cherbourg Promontory.**
nd, ...	**Brighton,** North coast of Norfolk.
y, ...	Flekkifiord, West of the Naze, Sytle Fiord, *Valley of the Tanie R.*
embla,	
. . . . .	Jigansk, on the Lena; South-east course of the R. Lena.
Okhotsch, . .	Shanter Is.
R., ...	Mouths of.
n Is., ...	**Jesso Is.,** north-east point of.
and Santa Cruz Is., .	Passes between them.
ledonia, . . .	South-east point of, Loyalty Is.
ster, . . .	C. and Mt. Egmont, Cooke's Sound.
hetland.	
eorgia Is.	
. . . .	West coast, Bissagos Is.; Morocco, West coast from C. Blanco to C. Juby.

No. 12.—SOUTHERN BOUNDARY TERTIARY FORMATION, U[N]
STATES.

Gulf of Mexico,	Victoria Fort.
Canada,	Lake Erie, Buffalo, **Lake Ontario**, Trent[…] **St. Lawrence** (parallel to course of), O[…] Anticosti Is. (north-west point of), **New B[…]wick**, **Coast of the R. St. Lawrence.**
Labrador,	South Coast, York Point, Straits of Belle-Is[…]
Ireland,	Shannon Mouth, Foynes.
Wales,	**South Coast, St. Bride's Bay, Oysterm[…] Weston-super-Mare.**
England,	**Mendip Hills, Southampton.**
France,	**North of Dieppe.**
Switzerland,	**Basle.**
Tyrol,	**Trent.**
Italy,	**Venice.**
Dalmatian Coast,	**Herzegovina and Montenegro.**
Turkey,	**Monastir**, North of Mt. Olympus.
Ægean Sea,	Skyros, Cos, **Rhodes.**
Syrian Coast,	El Arish.
Arabia,	Mt. Siebam, C. Guardafiu.
South Pacific,	Pamuan Is.
Mexico,	West Coast, near Guadalajala; C. Corri[…] Zacatecas Territory.

No. 14.—NORTH COAST OF AFRICA.

Ceuta,	**Alboran Is., Coast of Algiers.**
Sicily,	**Mt. Etna.**
Morea,	**Argos.**
Asia Minor,	**South Coast of**, Malesso, Saletkeh.
Cyprus,	North of.
Syria,	**Antioch, Aleppo.**
Persia,	**Ispahan.**
Beloochistan,	Khozdar, Sheivan.
India,	**Viziampatam.**
Andeman Is.,	North Sentinel.
Malaya.	
Borneo,	South-west point of.
Sambawa Is.,	East point of.
North Australia,	Cambridge Gulf; runs parallel to south coa[st] Carpentaria Bay.
New South Wales,	C. Byron.
New Ulster,	Bay of Islands.
Peru,	North-west point of, Loja, Lobos Is.
Ecuador,	Santa Rosa.
New Granada,	Moreno, Orinoco R. Mouths.
Madeira Is.,	St. Laurence.

No. 15.—WEST COAST OF PORTUGAL.

Mogador.	
Portugal,	C. St. Vincent, **Lisbon, Oporto.**
Spain,	**Vigo, Santiago, Corunna.**
Ireland,	Waterford, Coast of Antrim.

land,	**Mull and Skye Is.**
e Is.,	Eastern group of.
bergen,	Hackluyts Headland.
Siberia,	Nigui-Kolinsk.
ai Kamtschatka Coast.	
uito Group.	
Hebrides,	Southern Group of, **Tanna Is.**
Munster,	C. Foulwood to Ashburton.
ia (Africa),	Monrovia Town.
ra (Africa),	Parallel to line from C. Blanco to C. Verd.

No. 16.—EAST COAST OF ENGLAND.

outh,	Pentland Head.
e Is.,	Sunderoe.
nland,	Scoresby's Sound, C. York.
w's Straits,	Victoria Land.
da,	Great Bear Lake, North-west point of.
ka,	Sitka Is., Falls of R. Francis.
wich Is.,	1° 20′ to the east of.
rby's Land.	
a,	Kaffraria Coast, R. Untainvoona, **North-east coast of Tunis.**
inia,	**Cagliari,** Asinara Is.
ce,	**Antibes, Chambery, Dijon, Laon, Chalons.**

No. 23.—CAUCASUS MOUNTAINS.

an Mountains and if,	Naphtha Springs.
Azof.	
,	Parallel to the course of the Dnieper.
thians,	North side of, Eighteen miles south of Lublin.
any,	**Berlin** and **Potsdam.**
nd,	**Zuyder Zee,** Texel.
nd,	North coast of Norfolk, **Nottingham, Derby.**
s,	**Carnarvon Promontory.**
d,	**Wicklow,** Shannon (lower course of).
India Is.,	Windward Pass.
al America,	Costa Rica and Panama frontier, between ***Mount*** *Chirigin* and *Pico Blanco.*
pagos Is.,	**Easter Is.**
nd Is.,	South of.
Australia,	South-west part of Seal Is., West Coast, Arrowsmith R. Mouth.
	East Coast, Sadras.
Is.,	**Surat,** Gulf of Cambay, **Hyderabad.**
nistan,	Kelat.
,	Nisapoor.

No. 24.—SOUTH-EAST COAST OF AFRICA (FROM SOFALA SOUTHWARDS).

Sofala,	C. Corrientes.
Marian and Crozettes Is.,	1° west of.
South Victoria,	Cook's or Harvey's Is. Group.
North America,	Queen Charlotte Is., Provost Is., Wellingto North Devon Is. (C. Horsborough).
Greenland,	Melville Bay, Davy's Sound, Verner Mount
Europe,	Mouths of Weser R., **Minden, Hanover tingen, Bamberg, Noric Alps, Carnic**
Italy,	**Undine, Gulf of Trieste, Adriatic,** Pola parallel to coast between **C. Policestro Santa Euphemia, Basilicata, Cosenz**
Africa,	East coast of G. of Sidra, East coast of Tang Lake.

No. 28.—AXIS OF SUMATRA.

Nicobar Is.	
East Coast of India,	**Bomlipatam.**
India,	Mooltan, **Lehree Fort, Cabul,** near Candah
Caspian Sea,	Karaboghaz Bay, **Derbent.**
Caucasus,	**Ekaterinodar.**
Sea of Azof,	Czernowicz.
Carpathian Mountains,	Hungary, **Kesmak.**
Moravia,	**Bohemia,** Ireslau.
Germany,	**Odenwald, Wurtzburg, Worms.**
Rhine,	**Luxembourg.**
France,	**Brittany, Rouen, Caen,** C. Ushant.
Jersey.	
Azores,	About 2° north of.
West India Is.,	Spanishtown.
South America,	**Paraguana Peninsula, L. Mascaybo, Granada, Medelin,** Bay of Choco.
Ecuador and Granada,	North-west coast, from Beneventura Bay Lorenz.
New Zealand,	South point of, South-west Cape, Long Is.
Tasmania,	North point of.
Australia,	Coast-line from Geelong to Australian Bight
Java Is.,	South-west point.

No. 32.—NORTH-EAST COAST OF PERSIAN GULF.

Euphrates R. Valley,	**Bagdad,** thirty miles south-west of.
Aleppo,	**Head of Iskanderoon Gulf.**
Asia Minor,	**Taurus Chain, Konieh, Karahissar, Bro**
Sea of Marmora,	**Gallipoli.**
Turkey,	About forty miles south of **Sophia, Bosnia S**
Dalmatian Coast,	**Zara.**
Italy,	**Po River Valley, Mantua, Milan, Cham**
France,	Rhone, at **Lyons.**
Cuba Is.,	**Buena Esperanza Bay.**
Nicuaragua,	Near the Lake, Leon.
New Zealand,	North point of Long Is.
Tasmania,	South point.
Australia,	South-west Promontory.
Lacadive Is.	
Arabia,	Muscat Coast.

No. 50.—PROMONTORY OF NEW ULSTER.

ia, Van Diemen.	
America,	**Patagonia**, Port Santa Cruz, C. Frio, and Coast-line to Espiritu Santo.
-**west Africa**,	From C. Blanco to Mazagran.
	Guadalquiver R., **Seville, Toledo.**
ees,	**Pic du Midi, Bagniere de Bigorre.**
e,	**Cantal, Chalons sur Rhone.**
ny,	**Strasburg, Mannheim, Heidelberg, Wurtzburg, Darmstadt, Weimar, Leipzig,** Danzig.
	Ural Mountains, Pas Mer Mountains.
	Course of Obi at Surgutoi, **Backal Lake, Oudonsk.**
	Corea, Kinsin Is., *Solomon Is.*

No. 51.—EAST COAST OF SWEDEN.

ona, Stockholm, **Gefle, Hermosand, Umea.**

Cape.	
	Tchaon G., Amtschitka Is., **Alustran Is.**
Is.,	Oyolava Is.
c Ocean,	St. Thomas Is.
	Niger Mouths (parallel to Gaboon Coast), **Tunis,** C. Bon and East Coast.
	Rome to Pesaro.
c,	**Trieste Coast and Gulf, Undine.**
,	**Carnie Alps, Styria.**
nia,	**Prague.**

No. 53.—EAST COAST OF NEW ZEALAND.

a Land.	
a and Crozetto Is.	
Africa,	C. Vidal.
rs,	**Timencen, Hilat.**
,	**Vera, Lorca,** Madrid, **Escurial,** C. Ortugal.
and,	South-east Coast, Baffin's Is., Chesterfield Inlet.
uver's Is.,	North point.

No. 52.—WEST COAST OF SWEDEN.

land,	Ardencaple Inlet.
America,	Smyth's Straits, Alexander Cape, Great Bear Lake, Graham Is.
Victoria,	*Mount Erebus.*
	Sofala Coast, Lybian Coast.
,	Axis of.

No. 66.—SOUTH-WEST COAST OF AUSTRALIA.

Tasmania,	South point.
New Munster,	From Milford Sound to Ashburton.
Gambar Is.,	Paumoa Group.
Central America,	**Guatemala**, Quisaltenango to C. Catoche.
Cuba,	North-west Coast.
North America,	Florida Point.
Spain,	**Pyrenees**, and Santander Coast.
Sardinia,	Straits of Bonifacio.
Southern Italy,	**Catanzaro.**
Candia Is.	
Red Sea,	Head of Gulf of Acaba.
Arabia,	South Coast, Dofar.

These details show that the great circles marked on the map of Europe, in connexion with earthquake disturbances, traverse outside Europe, countries and districts more or less markedly subject to earthquakes, or volcanic in their nature, and therefore it would be possible to refer to such great circles the several earthquakes occurring on their directions. This would be a first method of grouping, and would allow of comparisons as regards contemporaneity, or, what is of equal interest, regularity of interval between the shocks occurring at points distantly removed.

The referring of earthquakes to great circle directions would, furthermore, facilitate the definition of those large extents of globe surface affected by great earthquakes, such as that of Lisbon in 1755, which can be very conveniently defined in this manner. Such earthquakes, and indeed many others, have usually been represented as extending over an ellipsoidal or circular space. This mode of definition can only be approximative, and when the limits are at all accurately determined, the surface affected usually presents a polygonal form. Thus the great earthquakes of 1811–13 are marked on Berghaus' map as extending over a triangular space, having for summits the Azores, the valley of the Ohio, and New Granada, that is to say, a polygonal form capable of being defined by segments of great circles.

The northern side of this triangle corresponds fairly with the great circle (No. 55) axis of Bay of Fundy, which runs from Madeira to Omaha (Nebraska State), about the extent of that side of the triangle. It might, therefore, be correct, and would be convenient, to refer and define earthquakes relatively to the great circles along which or near the intersections of which they occur. This I have done in the present memoir for the Central Saxony earthquake district, so remarkably connected with the great circle directions No. 50 and No. 2, and parallels.

I have also taken the records for 1870–78, and referred the successive earthquakes to great circle directions with very interesting results; and in certain cases, where the limiting points are given, the concordance of the boundaries of the locality affected, with the coastline directions passing thereat, is very remarkable.

Of the lines correlated with the great circles, and marked on the p, the following are the most remarkable :—

Great Circles.	Lines.	Angle of Correlation.
ith No. 5.—Coast of Syria.	Axis of Cyprus, ...	40°.
" " "	Black Sea Coast, Environs of Kerasun and Trebizonde, ...	70°.
" " "	North-east Coast of Black Sea, Circassian Coast, ...	70°.
" " "	West Coast of Caspian Sea, between mouths of Volga and Gulf of Kama, ...	Parallel to.
" " "	Volga Course, between Tzaritzin and Caspian Sea, ...	70°.
" " "	Volga Course, between Tzaritzin and Kamishin, ...	Parallel to.
" " "	Ural Range, from Shadmatra to Ekatermburg, ...	40°.
" " "	Ural Range, north of Shadmatra, .	Parallel to.
" " "	North Coast of Lapland and Timan Range, ...	70°.
" " "	East Coast of Black Sea, between Anaklia and Fort Santa Nickolai,	40°.
ith No. 16.—East Coast of England.	Catania, Coast of Sicily, and West Coast of Gulf of Taranto, . .	40°.
ith No. 6.—West Coast of Africa.	Murcia Earthquake Zone, . .	70°.
" " "	Ebro R. Valley Line (an Earthquake Line), ...	40°.
th No. 32.—North-east Coast of Persian Gulf.	Line joining Bosphorus and South-east Coast of Crimea (an Earthquake Line), ...	70°.
" " "	South-east Coast of Adriatic, from Aolona to Alessio, . . .	80°.

t Circles.	Lines.	Angle Correlat
51.—East Coast den.	Coast of Tripoli, from Jerba Is. to C. Mesurata.	80°.
,, ,,	South Coast of Gulf of Sidra, from Zafran to Kudia, . . .	80°.
,, ,, ,,	North-west Coast of Gulf of Cabes, .	40°.
,, ,, ,,	Line joining Kalibia (Cape Bon), Malta and Barca Coast, . .	80°.
,, ,, ,,	Sout st of Sicily, . . .	70°.
,, ,, ,,	ast of Gulf of Finland Bay), ...	70°.
,, ,, ,,	Shore of Lake Farouri , ...	70°.
With No. 52.—West Coast of Sweden.	South Co st of Crete, . . .	70°.
,, ,, ,,	Coast Egypt, from Milhr Bay to G Bay, ...	70°.
,, ,, ,,	Axis of Euboea Is., ...	40°.
,, ,, ,,	Axis of Lake Wetter, ...	40°.
,, ,, ,,	East Coast of Œland Is., . . .	40°.
,, ,, ,,	East Coast of L. Wener and Axis of Porsanger Fiord, . . .	40°.
,, ,, ,,	General direction of Kiolin Mountains, ...	40°.

XXIII.—A GEOMETRICAL REPRESENTATION OF A SYSTEM OF TWO BINARY CUBICS AND THEIR ASSOCIATED FORMS. By W. R. WESTROPP ROBERTS, M.A.

[Read, November 14, 1881.]

I.

HE object of this Paper is to invest with a certain geometrical meaning e algebraic forms arising in a system of two binary cubics, that is, construct geometrically points which shall represent the linear, qua- atic, cubic, and quartic covariants of the system, and to express the nishing of invariants by geometrical relations connecting such points. e may consider any binary quantic as derived from a system of three rfaces by assuming

$$X=\phi_1(x_1x_2),\quad Y=\phi_2(x_1x_2),\quad Z=\phi_3(x_1,x_2),\quad W=\phi_4(x_1,x_2),$$

uations which in themselves imply, by elimination of x_1 and x_2, two ed relations between X, Y, Z, W, denoting a fixed curve in space, hile the given binary quantic, equated to zero, enables us to obtain third such relation. The transformation here employed is one in hich ϕ_1, ϕ_2, ϕ_3, ϕ_4 are cubic functions of x_1 and x_2. By linear trans- rmation this substitution is reducible to

$$X=x_1^3,\; Y=x_1^2x_2,\; Z=x_1x_2^2,\; W=x_2^3,$$

he fixed curve in this case being evidently a twisted cubic. The quation of an osculating plane of the curve, the parameter of the rresponding point of which is $x_1:x_2$, being (Salmon's *Geometry of Three Dimensions*, Art. 368)

$$Xx_2^3-3Yx_2x_1^2+3Zx_1^2x_2-x_1^3W=0,$$

he parameters answering to osculating planes through any point O, he co-ordinates of which are X', Y', Z', W', are given by the quation

$$x_2^3X'-3Y'.x_2^2x_1+3Z'.x_1^2x_2-x_1^3W'=0,$$

he points of contact lying in the plane

$$XW'-3YZ'+3Y'Z-WX'=0.$$

But this plane passes through O, the given point. To any plane, then, corresponds a point O, the point of intersection of the osculating planes at the points where it meets the curve—a point which plays an

t in the following investigation. It can readily be shown it O' lie in the plane corresponding to a point O, then plane corresponding to O', and the line joining O and O' ertain invariant relation to the curve. Also the locus of ding points of planes passing through a given line is a which may be called the corresponding line to the given relation being reciprocal.

s now consider the binary cubic—

$$f = a_0x_1^3 + 3a_1x_1^2x^2 + 3a_2x_1x_2^2 + a_3x_2^3 = a_x^3 = b_x^3 = c_x^3, \text{ \&c.},$$

ting Clebsch's notation.

y our transformation the binary cubic is transformed into a plane equation of which is—

$$a_0X + 3a_1Y + 3a_2Z + a_3W = 0.$$

Now it can be easily shown that the corresponding point of this plane is given by the equations

$$X = a_3, \quad Y = -a_2, \quad Z = a_1, \quad W = -a_0.$$

We shall call it the point O.

II.

It is known that through any point O in space can be drawn one chord, meeting the curve in two points. Let us now determine these points, being given the point O.

The co-ordinates of the line joining the points on the curve, the parameters of which are $x_1 : x_2$, $y_1 : y_2$, respectively, are easily found to be—

$$\begin{aligned} a &= \Delta_0\Delta_2, & f &= 4\Delta_1^2 - \Delta_0\Delta_2, \\ b &= 2\Delta_1\Delta_2, & g &= -2\Delta_1\Delta_0, \\ c &= \Delta_2^2, & h &= \Delta_0^2, \end{aligned}$$

where

$$\Delta_0 = x_2y_2, \; 2\Delta_1 = x_1y_2 + y_1x_2, \; \Delta_2 = x_1y_1.$$

Now take two equations of the chord, viz.:—

$$\begin{aligned} aX + bY + cZ &= 0, \\ hY - fZ + aW &= 0, \end{aligned}$$

and these furnish us with—

$$\begin{aligned} \Delta_0X + 2\Delta_1Y + \Delta_2Z &= 0, \\ \Delta_0Y + 2\Delta_1Z + \Delta_2W &= 0. \end{aligned}$$

If we now suppose $X=a_3$, $Y=-a_2$, $Z=a_1$, $W=-a_0$, the equation determining the parameters of the two points in which the chord through O, the corresponding point of f, meets the curve is—

$$(a_0a_2-a_1^2)x_1^2+(a_0a_3-a_1a_2)x_1x_2+(a_1a_3-a_2^2)x_2^2=0.$$

But this is the equation of the Hessian of f, or—

$$\Delta_x^2=\Delta_0x^2+2\Delta_1x_1x_2+\Delta_2x_2^2.$$

Thus, then, to the Hessian of f correspond the two points in which the chord through O meets the curve.

III.

I shall now show that the plane f passes through the line of intersection of the osculating planes at the two Hessian points. To prove this, let us find the equation of the plane through O and this line.

Let

$$X',\ Y',\ Z',\ W';\quad X'',\ Y'',\ Z'',\ W'',$$

be the co-ordinates of the two Hessian points, respectively, then the equation of such a plane must be—

$$\lambda(XW'-3YZ'+3ZY'-WX')-\mu(XW''-3YZ''+3ZY''-WX'')=0,$$

where

$$\lambda=a_0X''+3a_1Y''+3a_2Z''+a_3W'',$$
$$\mu=a_0X'+3a_1Y'+3a_2Z'+a_3W'.$$

Remembering that

$$x_1y_1=a_1a_3-a_2^2,$$
$$x_1y_2+y_1x_2=a_0a_3-a_1a_2,$$
$$x_2y_2=a_0a_2-a_1^2,$$

we find, dividing by a factor $y_1x_2-x_1y_2$, that the equation of the sought plane is—

$$R\{a_0X+3a_1Y+3a_2Z+a_3W\}=0.$$

Hence the plane f passes through the line of intersection of the osculating planes at the Hessian points. If, then, the chord through O meet the cubic in real points, the plane f must meet it in two imaginary points, since the binary cubic is then the difference of two cubes.

IV.

Let us now determine the co-efficients of the plane

$$\lambda(XW' - 3YZ' + 3ZY' - WX') + \mu(XW'' - 3YZ'' + 3ZY'' - WX'') = 0,$$

and we find, after a few obvious reductions, that it becomes—

$$R\{(a_0^2a_3 - 3a_0a_1a_2 + 2a_1^3)X + 3(a_0a_1a_3 + a_1^2a_2 - 2a_0a_2^2)Y + 3(2a_1^2a_3 - a_0a_2a_3 - a_1a_2^2)Z + (3a_1a_2a_3 - a_0a_2^2 - 2a_2^3)W\} = 0,$$

but this is the cubic covariant plane Q.

We see, then, that the planes f and Q are harmonically conjugate with regard to the osculating planes at the Hessian points, and that since the Hessian of the cubic Q_x^3 is the same as that of a_x^3, the corresponding point of the plane Q lies on the chord through O, and is the harmonic conjugate of O with regard to the Hessian points. Hence, to the cubic covariant corresponds the plane through the intersections of the osculating planes at the Hessian points and the harmonic conjugate on the chord through O of the same point with regard to the Hessian points. Again, if the point O lie at one side of the developable generated by tangent lines to the cubic curve from which a real chord can be drawn, two of the roots of the binary cubic are imaginary; if the point O lies on the developable, two roots are equal; and if at the other side, from which a real chord cannot be drawn, all the roots are real.

V.*

We can now discuss the system of two binary cubics and their associated forms, and shall adopt the notation of Clebsch in our investigation. Let then f and ϕ denote the two cubics, Δ and ∇ their Hessians, Q and K their cubic covariants, and R and P their discriminants.† We have then

$$f \equiv a_0x_1^3 + 3a_1x_1^2x_2 + 3a_2x_1x_2^2 + a_3x_2^3 = a_x^3 = b_x^3 = c_x^3 = \&c.;$$
$$\phi \equiv \alpha_0x_1^3 + 3\alpha_1x_1^2x_2 + 3\alpha_2x_1x_2^2 + \alpha_3x_2^2 = \alpha_x^3 = \beta_x^3 = \gamma_x^3 = \&c.$$

There is one quartic form, $(a\alpha)\, a_x^2\alpha_x^2$, which we shall first discuss. The co-ordinates of the line of intersection of the planes f and ϕ are,

$$\begin{aligned} a &= a_0\alpha_3 - a_3\alpha_0, & f &= 9\,(a_1\alpha_2 - a_2\alpha_1), \\ b &= 3\,(a_1\alpha_3 - a_3\alpha_1), & g &= 3\,(a_2\alpha_0 - a_0\alpha_2), \\ c &= 3\,(a_2\alpha_3 - a_3\alpha_2), & h &= 3\,(a_0\alpha_1 - a_1\alpha_0), \end{aligned}$$

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* See Note at end of this Paper.

† The reader is referred to Clebsch's *Theorie der Binären Algebraischen Formen*, § 61. Vollständiges System zweier cubischen Formen.

while the co-ordinates of a tangent line are

$$\begin{aligned} a &= x_1^2 x_2^2, & f &= 3x_1^2 x_2^2, \\ b &= -2x_1^3 x_2, & g &= 2x_1 x_2^3, \\ c &= x_1^4, & h &= x_2^4. \end{aligned}$$

Forming then the well-known condition that these lines should meet, we find

$$x_1^4(a_0\alpha_1 - \alpha_0 a_1) + 2x_1^3 x_2(a_0\alpha_2 - a_2\alpha_0) + x_1^2 x_2^2\{a_0\alpha_3 - a_3\alpha_0 + 3(a\,a_1\alpha_2 - \alpha_1 a_2)\}$$
$$+ 2x(a_1\alpha_3 - \alpha_1 a_3)\, x_1 x_2^3 + (a_2\alpha_3 - a_3\alpha_2)\, x_2^4 = 0,$$

or,

$$(a\alpha)\, a_x^2 \alpha_x^2 = 0.$$

Hence, to the Jacobian of f and ϕ correspond the four points on the curve, the tangents at which meet the line f, ϕ.

It is to be observed that these four lines also meet the line corresponding to the line f, ϕ. The Jacobian is thus geometrically shown to be a combinantive covariant, since it depends only on the position of the line f, ϕ.

VI.

In addition to the forms f and ϕ, and their cubic covariants, there are two cubic forms,

$$(a\nabla)\, a_x^2 \nabla_x,\ (\alpha\Delta)\, \alpha_x^2 \Delta_x,$$

which we now discuss.

Since the cubic covariant of the binary cubic is the evectant of its discriminant, it follows easily that the cubic covariant plane is the polar plane of the point O with regard to the developable.

By taking the polar plane of a point on the line OO' we find it to be of the form

$$\lambda^3 Q + \lambda^2 \mu q + \lambda \mu^2 k + \mu^3 K = 0.$$

Hence we have two new planes, q and k, giving rise to two cubic covariants in the binary system, the leading terms of which are

$$qo = \alpha_0 \frac{dQ}{da_0} + \alpha_1 \frac{dQ}{da_1} + \alpha_2 \frac{dQ_0}{da^2} + \alpha_3 \frac{dQ_0}{da_3},$$

$$k_0 = a_0 \frac{dK_0}{d\alpha_0} + a_1 \frac{dK_0}{d\alpha_1} + a_2 \frac{dK_0}{d\alpha_2} + a_3 \frac{dK}{d\alpha_3},$$

where

$$\begin{aligned} \phi_0 &= a_0^2 a_3 - 3a_0 a_1 a_2 + 2a_1^3, \\ K_0 &= \alpha_0^2 \alpha_3 - 3\alpha_0 \alpha_1 \alpha_2 + 2\alpha_1^3. \end{aligned}$$

y to show that

$$q_0 = 3\{a_0(a_0 a_3 - a_1 a_2) - 2a_1(a_0 a_2 - a_1^2)\} + \{a_0 a_3 - a_3 a_0 \ - 3(a_1 a_2 - a_1 a_2)\} a_0$$
$$= 6\{a_0 \Delta_1 \ - a_1 \Delta_0\} + (aa)^3 a_0 :$$

$$q_x = 6(a\Delta)a_x^2 \Delta_x + (aa)^3 b_x^3.$$

in the same way

$$k_x = 6(a\nabla)a_x^2 \nabla_x - (aa)^3 \beta_x^3.$$

We have now expressed q in terms of Clebsch's forms, and represent them as follows: covariant q_x^3 is transformed into ne which is the polar plan with regard to the polar quadric .

In like manner k_x^3 is transform nto a plane which is the polar ne of O with regard to the p uadric of O'. These theorems immediate algebraic conseq c of the method of generation of covariants q and k.

VII.

We now discuss Clebsch's two ar covariants p_x and π_x.

If through a point $X, Y, Z,$ W, nd two points on the curve, the parameters of which are given by the equation

$$\Delta_x^2 = \Delta_0 x_1^2 + 2\Delta_1 x_1 x_2 + \Delta_2 x_2^2 = 0,$$

we draw a plane, it will meet the curve in a third point determined by the equation

$$x_1\{\Delta_0 Y + 2\Delta_1 Z + \Delta_2 W\} + x_2\{\Delta_0 X + 2\Delta_1 Y + \Delta_2 Z\} = 0.$$

And if we suppose that Δ is the Hessian of f, and that the point X, Y, Z, W is the corresponding point O' of the plane ϕ, we find the above equation becomes

$$(\Delta a)^2 a_x = 0, \text{ or } p_x = 0.$$

Hence the linear covariant p_x is represented by the point in which a plane through O', and containing the chord through O, meets the curve, a similar construction representing π_x, where $\pi_x = (\Delta a)^2 a_x$.

VIII.

We now turn to the quadratic covariants. The equation determining the parameters of the points in which a chord through any point on the line OO' is

$$\lambda^2 \Delta_x^2 + 2\lambda\mu\Theta_x^2 + \mu^2 \nabla_x^2 = 0.$$

The forms Δ and ∇ have been discussed before, and it remains to attach a geometrical meaning to $\Theta_x^2 = (a\alpha)^2 a_x \alpha_x$. Now, from any given point on the curve can be drawn two chords which will meet the line OO', the above equation in $\lambda : \mu$ determining the points of meeting on OO'; if, then, the co-efficient of $\lambda\mu$ is zero, the chords drawn from the given point meet the line OO' in two points harmonically conjugate with regard to O and O'.

Hence Θ_x^2 is represented geometrically by the two points on the curve; the chords from which, to meet the line OO', divide it harmonically.

IX.

Let us now determine the tangent lines to the curve which meet a line through X, Y, Z, W, and a point on the curve the parameter of which is $x_1' : x_2'$.

The co-ordinates of a line through X, Y, Z, W, and a point $x_1' : x_2'$ on the curve, are

$$\begin{aligned} a &= x_1'^2 x_2' Z - x_1 x_2'^2 Y, & f &= x_1'^3 W - X x_2'^3, \\ b &= x_1' x_2'^2 X - x_1'^3 Z, & g &= x'^2 x_2' W - X x_3'^3, \\ c &= x_1'^3 Y - x_1'^2 x_2 X, & h &= x_1' x_2'^2 W - Z x_2'^3, \end{aligned}$$

forming the condition that this line may meet a tangent line, the co-ordinates of which are given by V., and dividing by a factor

$$(x_1 x_2' - x_2 x_1')^2,$$

we find

$$x_1^2 (W x_1' - Z x_2') + 2 x_1 x_2 (Y x_2' - Z x_1') + (Y x_1' - X x_2') x_2^2 = 0.$$

Suppose now the point X, Y, Z, W to be the point O, and the point on the curve, the point p_x or $(\Delta\alpha)^2 \alpha_x$, the above equation becomes

$$x_1^2 . (a_0 x' + a_1 x_2') + 2 x_1 x_2 . (a_1 x_1' + a_2 x_3') + (a_2 x_1' + a_3 x_2') x_2^2 = 0;$$

or $(ap) a_x^2 = 0$. We can easily express this in terms of Clebsch's forms as follows:—

$$\Theta_x^2 = (a\alpha)^2 a_x \alpha_x;$$

hence

$$2(\Theta\Delta)\Theta_x = (a\alpha)^2 \{a_x (\alpha\Delta) + \alpha_x (a\Delta)\};$$

therefore

$$\begin{aligned} 2(\Theta\Delta)\Theta_x \Delta_x &= a_x (\alpha\Delta)(a\alpha)(a\alpha)\Delta_x \\ &\quad + (a\alpha)^2 (a\Delta) \alpha_x \Delta_x = \\ a_x (a\alpha)(\alpha\Delta) &\{a_x (\Delta\alpha) + \alpha_x (a\Delta)\} + (a\alpha)^2 (a\Delta) \alpha_x \Delta_x \\ &= - a_x^2 (a\alpha)(\Delta\alpha)^2. \quad \text{(See Clebsch, § 34.)} \end{aligned}$$

Hence

$$(p a) a_x^2 = 2(\Theta\Delta)\Theta_x \Delta_x.$$

The three remaining quadratic covariants are constructed as follows:—

It remains to discuss the invariant $T = (\Delta\nabla)^2$. The vanishin
s invariant may be geometrically expressed in various ways. W
: 0, the planes through any chord and the four points in whicl
cnords through O and O' respectively meet the curve, form a
monic system. Again, when $T = O$, the polar quadric of O p
through O', and *vice versâ*.

In this investigation I have adopted throughout the notatio
procedure of Clebsch, which lends itself more readily than
methods to the identification of binary forms with their geom
significations.

NOTE ADDED IN THE PRESS.

For convenience, I give a list of the invariants and covarian
system of two cubics, of which there are, according to Clebs
Gordan, twenty-eight forms in all, and which I discuss geomet

Professor Cayley has, however, drawn my attention to t
that two of the linear covariants ($xa^4\alpha^3$ and $xa^3\alpha^4$) of Clebsch a
dan have been shown to be non-fundamental by Professor Sy
See Sylvester's "Tables of the Generating Functions," *A
Journal of Mathematics*, t. ii. (1879.)

Table of Covariants and Invariants of a System of Two Cub

Seven Invariants—

$$a\alpha;\quad a^4,\quad a^3\alpha,\quad a^2\alpha^2,\quad a\alpha^3,\quad \alpha^4:\qquad a^3\alpha^3.$$

$$(a\alpha)^3;\ (\Delta\Delta')^2,\ (\Delta\Theta)^2,\ (\Delta\nabla)^2,\ (\nabla\Theta)^2\ (\nabla\nabla')^2,\ (\Theta\Delta)\ (\Theta\nabla)\ (\Delta\nabla$$

Six Linear Covariants—

$$xa^2\alpha,\quad xa\alpha^2;\qquad xa^4\alpha,\qquad xa^3\alpha^2,\qquad xa^2\alpha^3,\qquad xa$$

$$(\Delta\alpha)^2\alpha_x,\ (\nabla a)^2 a_x;\ (a\Delta)^2(a\Delta')\Delta'_x,\ (Q\nabla)^2 Q_x\ (K\nabla)^2 K_x,\ (a\nabla)^2(a$$

Six Quadratic Covariants—

$$x^2a^2,\ x^2a\alpha,\ x^2\alpha^2,\quad x^2a^3\alpha,\quad x^2a^2\alpha^2,\quad x^2a\alpha^3,$$

$$\Delta_x^2,\ \ \Theta_x^2,\ \ \nabla_x^2\ (\Delta\Theta)\Delta_x\Theta_x,\ (\Delta\nabla)\Delta_x\nabla_x,\ (\nabla\Theta)\nabla_x'\Theta_x.$$

Six Cubic Covariants—

$$x^3a,\ x^3\alpha,\ x^3a^3,\quad x^3a^2\alpha,\quad x^3a\alpha^2,\quad x^3\alpha^3.$$

$$a_x^3,\ \ \alpha_x^3,\ \ Q_x^3,\ (\Delta\alpha)\Delta_x\alpha_x^2,\ (\nabla a)\nabla_x a_x^2,\ K_x^3.$$

One Quartic Covariant—

$$x^4 a\alpha.$$

$$(a\alpha)a_x^2\alpha_x^2.$$

In this Table I have identified, at the suggestion of Profess
ley, the Covariants given by Sylvester, with the notation of
and Gordan.

XIV.—REPORT ON THE BOTANY OF THE MOUNTAINOUS PORTION OF CO. FERMANAGH TO THE WEST OF LOUGH ERNE, AND THE ADJOINING DISTRICT OF CO. CAVAN. By SAMUEL ALEXANDER STEWART, Fellow of the Botanical Society of Edinburgh, Curator of the Collections in the Museum of the Belfast Natural History and Philosophical Society.

[Read, February 27, 1882.]

region to which this Report has reference is included in two ties, Cavan and Fermanagh, and lies near the western extremity District X. of the "Cybele Hibernica." That portion of Fer-agh situated near the western and south-western boundaries of county possesses a more diversified surface than the eastern ion, and the numerous ranges of hills attain a much higher ation. Even here, however, except where it adjoins Cavan, it scarcely be called mountainous, but rather hilly and rocky. Drumbad, near Lough Melvin, on the extreme west of Fer-agh, there is an elevated plateau, extending for several miles, re the hill-tops rise, in places, to over 1000 feet. This is the hern end of a system of hills and highlands that stretches hwards to Lough Macnean, and the borders of county Cavan, inating in Belmore Mountain, near Belcoo. Belmore has an ude of 1312 feet, while several other summits, at this end of range, attain to heights of 1000 to 1200 feet. On passing over boundary, and entering the north-west side of Cavan, the coun-becomes more decidedly mountainous; several summits approach 0 feet, and Cuilceagh exceeds that altitude. The rock strata consist, he lower levels, of carboniferous limestone, rising to somewhere at 1000 feet; the rock being, in many places, exposed in low s and crags, which often impart a picturesque aspect to scenery rwise tame. Superimposed on these rocks we find, at higher ations, thin beds of black shale, capped by massive, thick-bedded, dstones and grits, forming a series of bare, bleak, uninviting ntains, unproductive alike to the botanist and the agriculturist. Though the Shannon has here its origin, yet there is no river of any nitude flowing through the district; but many small lakes lie in ty hollows amongst the hills, while more extensive sheets of water l the surface of the level country in all directions. It will be rved that the number of plants in the present list is not very e, a result which is due to several causes. The district being gether inland, plants of the seashore, and those that prefer the ximity of the coast, are absent. The number is still further

restricted by the nature of the ground over which my observations extended, which is almost entirely heathy and rocky, agricultural weeds being thereby, to a great extent, excluded. Nevertheless, there still remains the fact that a great degree of sameness was found to characterize the vegetation all over these mountains, and that the plants which have, in Britain, the widest range immensely preponderate. This will be shown if we analyze the list which follows, and compare its constituents with the entire Irish flora, as given in the "Cybele Hibernica." For the sake of clearness I shall, in stating the proportions as regards the prevalence of the several British types, disregard fractions; such a degree of exactness not being essential, seeing that there is often a doubt as to which type a plant should be referred. The Irish flora contains representatives of each of Watson's types of British vegetation, with the addition of a "Hibernian type," or a group of plants which do not occur in Great Britain. None of this latter group are included in my enumeration, and plants of Watson's "Germanic type" are also entirely absent. The "Atlantic type" forms four per cent. of the Irish flora, but only one per cent. of those on my list. Plants included in the "Highland type" make five per cent. of the species given in the "Cybele Hibernica," but only two per cent. of those in our district. Plants of the "Scottish type" constitute seven per cent. of Irish plants, but three per cent. only of this catalogue. The "English type" claims about twenty-four per cent. of the entire Irish flora, but only five per cent. of those in our limited area. The *Leguminosæ* and *Labiatæ* are especially strong in plants of the English type, but the paucity in this district of plants of these orders is apparent on reference to the subjoined list. Lastly, the "British type" of Watson, which includes the species most widely spread, and usually the most abundant, supplies about fifty-eight per cent. in number of the plants of Ireland, but gives a proportion of eighty-nine per cent. as regards this mountain district of Fermanagh and Cavan.

A very few plants which flower in early spring were not seen by me, and a few others could, no doubt, be added by any botanist having more protracted opportunities for the search; but the enumeration here given may be taken as substantially the flora of the district to which it refers. The only certain addition to the Irish flora, here recorded, is *Potamogeton zizii* (Roth), which I found, in small quantity only, in county Fermanagh. I have no doubt, however, but that this segregate will be found in other parts of the country, when carefully looked for. Professor Babington thinks that a bramble which I found in Fermanagh belongs to *Rubus emersistylus* (Mull.) = *R. briggsii* (Blox.) As the specimens gathered are rather scanty, and as Professor Babington does not speak with absolute certainty, there must still remain some doubt as regards this form. As this is an interesting plant, not previously recognized in Ireland, it is worthy of attention.

The following plants are additions to the flora of District X., not being recorded for that district in the "Cybele Hibernica," nor in the Supplement published by Mr. A. G. More, in 1872:—

Arabis hirsuta.
Sagina nodosa.
Linum catharticum.
Agrimonia eupatoria.
Rubus emersistylus.
Rosa arvensis.
Antennaria dioica.
Arctium nemorosum.
Hieracium anglicum.
H. lasiophyllum.
Gentiana campestris.
Myosotis cæspitosa.
Callitriche hamulata.
Habenaria viridis.
H. chlorantha.
Potamogeton zizii.
P. pectinatus.
Scirpus setaceous.
Phleum pratense.
Aira flexuosa.
Cystopteris dentata.
Chara aspera.

LIST OF SPECIES.

RANUNCULACEÆ.

Anemone nemorosa (Linn.)—Cavan and Fermanagh. Shady places in the hills.

Ranunculus flammula (Linn.)—Cavan and Fermanagh. Not at all abundant.

R. ficaria (Linn.)—Cavan and Fermanagh. Common in damp shady places.

R. acris (Linn.)—Cavan and Fermanagh. Common, and sometimes very luxuriant.

R. bulbosus (Linn.)—Knockmore, Co. Fermanagh. Not very common. NOTE.—I met with none of the Batrachian Ranunculi.

Caltha palustris (Linn.)—Cavan and Fermanagh. Frequent in wet fields and marshes.

NYMPHAEACEÆ.

Nymphæa alba (Linn.)—Cavan and Fermanagh. Frequent.

Nuphar lutea (Linn.)—Cavan and Fermanagh. Frequent; the two water-lilies seem to be about equally abundant.

CRUCIFERÆ.

Nasturtium officinale (R. Br.)—Cavan and Fermanagh. Common in ditches and slow streams.

Arabis hirsuta (R. Br.)—Very sparingly on the limestone cliffs at Knockmore, Co. Fermanagh.

Cardamine hirsuta (Linn.)—Cavan and Fermanagh. On walls and waste ground.

C. sylvatica (Link.)—Cavan and Fermanagh. Damp shady rocks.

C. pratensis (Linn.)—Frequent in Cavan and Fermanagh. Meadows and damp pastures.

Sisymbrium officinale (Scop.)—Cavan and Fermanagh. Roadsides and waste places.

Alliaria officinalis (Andrz.)—Co. Fermanagh. Occurs on limestone rocks at Knockmore, and occasionally on hedge banks.

Sinapis arvensis (Linn.)—Cavan and Fermanagh. Fields and waste places.

Capsella bursa-pastoris (D.C.)—Cavan and Fermanagh. Hedge banks and waste ground.

VIOLACEÆ.

Viola palustris (Linn.)—Frequent in Cavan and Fermanagh. Boggy ground in the hills.

V. sylvatica (Fries.)—Cavan and Fermanagh. Common.

DROSERACEÆ.

Drosera rotundifolia (Linn.)—Cavan and Fermanagh. Frequent in peat bogs.

D. anglica (Huds.)—Legland Mountain, Co. Fermanagh. Rare.

Parnassia palustris (Linn.)—Knockmore and Carrick, Co. Fermanagh—Local. Wet rocky places.

POLYGALACEÆ.

Polygala vulgaris (Linn.)—Cavan and Fermanagh. Common on heaths and dry hilly pastures.

CARYOPHYLLACEÆ.

Lychnis flos-cuculi (Linn.)—Cavan and Fermanagh. Meadows and damp pastures.

L. diurna (Sibth.)—Knockmore, Co. Fermanagh. Scarce, dry shaded rocks.

Sagina procumbens (Linn.)—Cavan and Fermanagh. Damp waste ground.

S. nodosa (E. Meyer.)—Co. Fermanagh. Rare; sparingly by the margin of Lough Navar, Drumbad.

Stellaria media (Linn.)—Common everywhere.

S. holostea (Linn.)—Shady rocks at Knockmore; perhaps common.

S. graminea (Linn.)—Not uncommon in Cavan and Fermanagh; seen occasionally.

Cerastium glomeratum (Thuil.)—Very abundant, especially on the limestone in Cavan and Fermanagh.

C. triviale (Link.)—Common in Cavan and Fermanagh, but less abundant than the preceding species.

Spergula arvensis (Linn.)—Common in fields.

HYPERICACEÆ.

Hypericum androsæmum (Linn.)—Marble Arch, &c., Co. Fermanagh. Not common.
H. perforatum (Linn.)—Carrick, Co. Fermanagh. Not common.
H. pulchrum (Linn.)—Cavan and Fermanagh. Common on heaths and dry banks.

GERANIACEÆ.

Geranium molle (Linn.)—Frequent in Cavan and Fermanagh.
G. lucidum (Linn.)—Frequent on the limestone rocks in Cavan and Fermanagh.
G. Robertianum (Linn.)—Cavan and Fermanagh. Common.

OXALIDACEÆ.

Oxalis acetosella (Linn.)—Common everywhere.

LINACEÆ.

Linum catharticum (Linn.)—Cavan and Fermanagh. Common.

LEGUMINOSÆ.

Ulex europæus (Linn.)—Cavan and Fermanagh. But not at all abundant.
Trifolium pratense (Linn.)—Cavan and Fermanagh. Common.
T. repens (Linn.)—Common everywhere.
T. minus (Sm.)—Common.
Lotus corniculatus (Linn.)—Common in Cavan and Fermanagh.
Anthyllis vulneraria (Linn.)—Knockmore, Carrick, &c. Frequent on the limestone rocks.
Vicia cracca (Linn.)—Common on hedge banks.
V. sepium (Linn.)—Cavan and Fermanagh. Frequent.
Lathyrus pratensis (Linn.)—Cavan and Fermanagh. But not at all abundant.

ROSACEÆ.

Prunus spinosa (Linn.)—Common everywhere.
Spiræa ulmaria (Linn.)—Frequent througout the district.
Agrimonia eupatoria (Linn.)—On limestone rocks at Knockmore, Carrick, &c.; but not common.
Alchemilla vulgaris (Linn.)—Cavan and Fermanagh. Frequent.
A. arvensis (Linn.)—Cavan and Fermanagh. Not uncommon in cultivated ground.
Potentilla anserina (Linn.)—Cavan and Fermanagh. But not abundant.
P. tormentilla (Nesl.)—Everywhere abundant.
P. fragariastrum (Ehr.)—Cavan and Fermanagh. Frequent.
Fragaria vesca (Linn.)—Common on the hills.

Rubus idæus (Linn.)—Limestone rocks at Knockmore; but not common.
R. discolor (W. and N.)—Abundant. This is the common bramble of the district.
R. koehleri (Weihe.)—Frequent throughout the district.
R. emersistylus (Müll.) = *R. briggsii* (Blox.)—Specimens which I gathered near Derrygonnelly, Co. Fermanagh, were submitted by my friend Mr. T. H. Corry, M.R.I.A., &c., to Professor Babington, who kindly examined them, and, as the result of his diagnosis, informs us that he thinks them to belong to *R. briggsii*. It is unfortunate that a suite of specimens sufficient to place the species beyond doubt was not collected. Brambles are sufficiently abundant in the district, but with less than the usual diversity of forms.
Dryas octopetala (Linn.)—Abundant in one spot on the summit of the limestone cliffs of Knockmore, at the western end. This plant is evidently the var. a., and is the same form as that which occurs on Ben Bulben, having the sepals beset with red glandular hairs.
Geum urbanum (Linn.)—Cavan and Fermanagh. Hedge banks; but not abundant.
G. rivale (Linn.)—Cavan and Fermanagh. Frequent on margins of streams.
Rosa tomentosa (Sm.)—Cavan and Fermanagh. Common.
R. canina (Linn.)—Cavan and Fermanagh. Common.
R. arvensis (Huds.)—Co. Fermanagh. Sparingly near Florence Court, on old road leading to Swanlinbar.
Cratægus oxyacantha (Linn.)—Cavan and Fermanagh. Common.
Pyrus aucuparia (Gaert.)—Carrick and Drumbad, Co. Fermanagh.

Onagraceæ.

Epilobium parviflorum (Schreb.)—Cavan and Fermanagh. Common.
E. montanum (Linn.)—Cavan and Fermanagh. But less plentifully than the preceding species.
Circæa lutetiana (Linn.)—Marble Arch, &c., Co. Fermanagh.

Haloragaceæ.

Myriophyllum alterniflorum (D. C.)—Carrick Lake, Co. Fermanagh.

Portulaceæ.

Montia fontana (Linn.)—Cavan and Fermanagh. Frequent in wet stony places.

Crassulaceæ.

Cotyledon umbilicus (D.C.)—Co. Fermanagh. On rocks at Carrick.

Saxifragaceæ.

Saxifraga hypnoides (Linn.)—Knockmore, Co. Fermanagh.
Chrysosplenium oppositifolium (Linn.)—Cavan and Fermanagh. Frequent on wet rocks.

UMBELLIFERÆ.

la europæa (Linn.)—Cavan and Fermanagh. Knockmore, Car-k, &c.
adum nodiflorum (Koch.)—Cavan and Fermanagh. Frequent.
dium podagraria (Linn.)—Cavan and Fermanagh. Common.
flexuosum (With.)—Cavan and Fermanagh. Knockmore, &c.
he phellandrium (Lam.)—Co. Fermanagh. Slow stream at west d of Carrick Lake.
um sphondylium (Linn.)—Cavan and Fermanagh. Common on aste ground.
anthriscus (Gaert.)—Cavan and Fermanagh. Everywhere abun-nt.
scus sylvestris (Hoffm.)—Frequent in Cavan and Fermanagh, t much less abundant than the preceding.

HEDERACEÆ.

helix (Linn.)—Cavan and Fermanagh. Common.

CAPRIFOLIACEÆ.

um opulus (Linn.)—Carrick, &c. Frequent in Co. Fermanagh.
a periclymenum (Linn.)—Cavan and Fermanagh. Common.

RUBIACEÆ.

la odorata (Linn.)—Cavan and Fermanagh. Shady places, but t abundant.
aparine (Linn.)—Cavan and Fermanagh. Very common.
m (Linn.)—Cavan and Fermanagh. Common.
tile (Linn.)—Cavan and Fermanagh. Common on the hills.
stre (Linn.)—Wet places. Common in Cavan and Fermanagh.

VALERIANACEÆ.

na officinalis (Linn.)—Carrick, &c. Frequent in Cavan and rmanagh.

DIPSACACEÆ.

a succisa (Linn.)—Cavan and Fermanagh. Common.

COMPOSITÆ.

go farfara (Linn.)—Cavan and Fermanagh. Frequent.
erennis (Linn.)—Common everywhere.
o virgaurea (Linn.)—Co. Fermanagh. Carrick, Knockmore, nts Mountain, &c. Not common.
a millefolium (Linn.)—Cavan and Fermanagh. Frequent.
themum leucanthemum (Linn.)—In the utmost profusion every-here.

Chrysanthemum segetum (Linn.)—Cavan and Fermanagh. Common in cultivated ground.

Antennaria dioica (Gaert.)—Cavan and Fermanagh. Grassy spots, Knockmore, Carrick, &c.

Senecio vulgaris (Linn.)—Common everywhere.

S. sylvaticus (Linn.)—Near Florence Court, Co. Fermanagh.

S. Jacobæa (Linn.)—Common everywhere.

S. aquaticus (Huds.)—Cavan and Fermanagh. Frequent.

Arctium nemorosum (Lej.)—On limestone rocks at Knockmore, Co. Fermanagh. Professor Babington, who kindly diagnosed my specimen, confirms the name.

Centaurea nigra (Linn.)—Common in Cavan and Fermanagh.

Carduus lanceolatus (Linn.)—Common everywhere.

C. arvensis (Curt.)—Cavan and Fermanagh; but less common than I have usually found it elsewhere.

C. palustris (Linn.)—Cavan and Fermanagh. Common.

C. pratensis (Huds.)—Cavan and Fermanagh. Frequent in damp pastures and meadows.

Lapsana communis (Linn.)—Cavan and Fermanagh. Common.

Hypochæris radicata (Linn.)—Roadsides and waste places. Common everywhere.

Apargia autumnalis (Willd.)—Carrick, Drumbad, &c. Frequent in Cavan and Fermanagh.

Leontodon taraxicum (Linn.)—Cavan and Fermanagh. Common everywhere.

Sonchus oleraceus (Linn.)—Cavan and Fermanagh. Roadsides and banks.

S. arvensis (Linn.)—Cavan and Fermanagh. Cultivated fields.

Crepis paludosa (Moench.)—Very common in Cavan and Fermanagh. It seems to replace *C. virens*, which I did not see.

Hieracium pilosella (Linn.)—Cavan and Fermanagh. Common.

H. anglicum (Fries.)—Cavan and Fermanagh. It occurs plentifully on limestone cliffs at Knockmore, and is found in more or less abundance at Carrick, Drumbad, Tents Mountain, and Cuilceagh.

H. cinerascens (Jord.) = *H. lasiophyllum* (Bab.)—Knockmore, Carrick and Badmore, Co. Fermanagh, but only in very small quantity. By the kindness of Mr. Backhouse, who examined my specimens of this and the preceding species, I am enabled to publish these names with certainty.

CAMPANULACEÆ.

Campanula rotundifolia (Linn.)—Cavan and Fermanagh. Frequent.

ERICACEÆ.

Calluna vulgaris (Salisb.)—Common on the hills.

Erica tetralix (Linn.)—Common on heaths.

EUPHORBIACEÆ.

Euphorbia helioscopia (Linn.)—Frequent in cultivated fields.
E. peplus (Linn.)—Cavan and Fermanagh. Frequent.

CALLITRICHACEÆ.

Callitriche verna (Linn.)—Carrick, &c. In streams.
C. hamulata (Kutz.)—Very luxuriant at Carrick, Co. Fermanagh.

URTICACEÆ.

Urtica dioica (Linn.)—Everywhere common.

AMENTIFERÆ.

Salix pentandra (Linn.)—Derrygonnelly and Carrick, Co. Fermanagh.
S. cinerea (Linn.)—Cavan and Fermanagh. Common.
S. aurita (Linn.)—Hilly places; frequent.
Myrica gale (Linn.)—Heaths and bogs; frequent.
Alnus glutinosa (Gaert.)—Cavan and Fermanagh. Common.
Corylus avellana (Linn.)—Hedges and glens; common everywhere.

CONIFERÆ.

Taxus baccata (Linn.)—Sparingly on limestone cliffs at Carrick, and Knockmore, Co. Fermanagh.

ORCHIDACEÆ.

Orchis mascula (Linn.)—Damp pastures; common.
O. maculata (Linn)—Meadows and damp ground; common.
Habenaria viridis (R. Br.)—Legland Mountain, Co. Fermanagh; sparingly.
H. chlorantha (Bab.)—Cavan and Fermanagh, Carrick, &c. Frequent.
Listera ovata (R. Br.)—Everywhere abundant, especially on the limestone.

IRIDACEÆ.

Iris pseud-acorus (Linn.)—Cavan and Fermanagh. Common.

LILIACEÆ.

Endymion nutans (Dum.)—Cavan and Fermanagh. Shady banks.

JUNCACEÆ.

Narthecium ossifragum (Huds.)—Cavan and Fermanagh. Frequent on heaths.
Juncus effusus (Linn.)—Everywhere common.
J. conglomeratus (Linn.)—Cavan and Fermanagh. Common.

Thymus serpyllum (Linn.)—On the hills; common.
Prunella vulgaris (Linn.)—Everywhere common.
Nepeta glechoma (Benth.)—Cavan and Fermanagh. F hedge banks.
Lamium purpureum (Linn.)—Cavan and Fermanagh. W common.
Galeopsis tetrahit (Linn.)—Cavan and Fermanagh. Freq
Stachys sylvatica (Linn.)—Cavan and Fermanagh. Sh common.
S. palustris (Linn.)—Cavan and Fermanagh. Comm places.
Ajuga reptans (Linn.)—Everywhere common.

LENTIBULARIACEÆ.

Pinguicula vulgaris (Linn.)—Cavan and Fermanagh. W the hills.

PRIMULACEÆ.

Primula vulgaris (Huds.)—Common everywhere.
Lysimachia nemorum (Linn.)—Cavan and Fermanagh. F
Anagallis arvensis (Linn.)—Fields and waste ground; co
A. tenella (Linn.)—Boggy ground, Drumbad, Co. Ferm white flowers; rare.

PLANTAGINACEÆ.

Plantago lanceolata (Linn.)—Hedge banks and pastures; c
P. major (Linn.)—Roadsides and wastes; common.
Littorella lacustris (Linn.)—Margin of Carrick Lake, Co. Not at all common.

POLYGONACEÆ.

Rumex conglomeratus (Murr.)—Cavan and Fermanagh. R banks.
R. obtusifolius (Linn.)—Roadsides and waste ground; co
R. crispus (Linn.)—Cavan and Fermanagh. Frequent.
R. acetosa (Linn.)—Cavan and Fermanagh. Hedge banks
R. acetosella (Linn.)—Mountain pastures; common.
Polygonum persicaria (Linn.)—Cavan and Fermanagh. and wastes.
P. hydropiper (Linn.)—Cavan and Fermanagh. Banks of wet places.
P. aviculare (Linn.)—Waste ground; common everywhe

EMPETRACEÆ.

Empetrum nigrum (Linn.)—Legland Mountain, near De Co. Fermanagh.

C. pilulifera (Linn.)—Cavan and Fermanagh. Mountain heaths; rather rare.
C. glauca (Scop.)—Everywhere common.
C. flava (Linn.)—Cavan and Fermanagh. Common.
C. hornschuchiana (Hoppe.)—Cavan and Fermanagh. Carrick, Cuilceagh, &c.
C. binervis (Sm.)—Cavan and Fermanagh. Frequent on mountain heaths.
C. sylvatica (Huds.)—Marble Arch, &c.; but not very common.
C. hirta (Linn.)—Cavan and Fermanagh. Not uncommon.

GRAMINEÆ.

Phalaris arundinacea (Linn.)—Cavan and Fermanagh. Common.
Anthoxanthum odoratum (Linn.)—Common everywhere.
Phleum pratense (Linn.)—Meadows and margins of fields; common.
Alopecurus pratensis (Linn.)—Marble Arch, &c.; but not at all common.
Nardus stricta (Linn.)—Cavan and Fermanagh. On heaths.
Phragmites communis (Trin.)—Cavan and Fermanagh. Occasionally in ditches and marshes.
Agrostis vulgaris (With.)—Cavan and Fermanagh. Common.
Holcus lanatus (Linn.)—Cavan and Fermanagh. Hedge banks and pastures.
Aira cæspitosa (Linn.)—Cavan and Fermanagh. Shady places; frequent.
A. flexuosa (Linn.)—Cavan and Fermanagh. Very common on heaths.
Arrhenatherum elatius (M. & K.)—Everywhere common.
Triodia decumbens (Beauv.)—Cavan and Fermanagh. Frequent on grassy heaths.
Melica uniflora (Retz.)—Carrick, &c., Co. Fermanagh. Shady rocks.
Molinia cærulea (Moench.)—Cavan and Fermanagh. On heaths; frequent.
Poa annua (Linn.)—Cavan and Fermanagh. Common.
P. trivialis (Linn.)—Common everywhere.
P. pratensis (Linn.)—Frequent throughout the district.
Briza media (Linn.)—Rocks at Carrick, Co. Fermanagh.
Cynosurus cristatus (Linn.)—Common everywhere.
Dactylis glomerata (Linn.)—Roadsides and pastures; everywhere.
Festuca rubra (Linn.)—Cavan and Fermanagh. Common.
F. pratensis (Huds.)—Carrick, &c. Not uncommon.
Serrafalcus mollis (Parl.)—Cavan and Fermanagh. Frequent.
Lolium perenne (Linn.)—Everywhere abundant.
L. italicum (A. Braun.)—Banks and pastures; frequent.

EQUISETACEÆ.

Equisetum arvensis (Linn.)—Abundant everywhere.
E. maximum (Lam.)—Cavan and Fermanagh. Frequent.

E. sylvaticum (Linn.)—Cavan and Fermanagh. Not uncommon.
E. limosum (Linn.)—Abundant everywhere.
E. palustre (Linn.)—Cavan and Fermanagh. Common.

FILICES.

Polypodium vulgare (Linn.)—Cavan and Fermanagh. Common.
Lastrea filix-mas (Presl.)—Common everywhere.
L. dilatata (Presl.)—Common everywhere.
L. æmula (Brack.)—Co. Fermanagh, Carrick and Drumbad. Beside rocky banks of streams.
Polystichum aculeatum (Roth.)—Cavan and Fermanagh. Not uncommon on the hills.
P. angulare (Newm.)—Common everywhere.
Cystopteris fragilis (Bernh.)—Cavan and Fermanagh. On damp rocks; common.
——Var. *b. dentata* (Sm.)—Frequent; along with the preceding.
Athyrium filix-fœmina (Roth.)—Cavan and Fermanagh. Frequent.
Asplenium adiantum-nigrum (Linn.)—Cavan and Fermanagh; but not abundant.
A. trichomanes (Linn.)—Everywhere common on shady rocks.
A. ruta-muraria (Linn.)—On walls and dry rocks; abundant everywhere.
Scolopendrum vulgare (Sym.)—Common everywhere.
Blechnum boreale (Sw.)—Common everywhere.
Pteris aquilina (Linn.)—On dry heaths; everywhere.
Hymenophyllum wilsoni (Hook.)—Knockmore, Drumbad, Cuilcagh, &c. Frequent in Cavan and Fermanagh.
Osmunda regalis (Linn.)—Carrick and Drumbad, Co. Fermanagh. Abundant and luxuriant by the streams.

LYCOPODIACEÆ.

Lycopodium selago (Linn.)—Cavan and Fermanagh. In great profusion on the mountains.
Selaginella spinulosa (A. Br.)—Damp shady rocks, Knockmore, and Drumbad, Co. Fermanagh; sparingly.

CHARACEÆ.

Chara aspera (Willd.)—Carrick Lake, Co. Fermanagh.

XV.—RECENT FORAMINIFERA OF DUBLIN AND WICKLOW. By FREDERICK PRYOR BALKWILL and JOSEPH WRIGHT, F.G.S.

[Read, February 27, 1882.]

the examination of the various gatherings of Foraminifera made year off the Dublin and Wicklow coasts have not yet been fully pleted, the present brief Report is now furnished, pending the iled results which we hope to have ready for publication next . The following particulars are given to show what has already accomplished. Previous to the grant having been given, one s had made a number of shore gatherings in the vicinity of lin, and the list of the Foraminifera found was sent to the demy at the time. Since then thirty dredgings have been red—three in Dublin Bay, the remaining twenty-seven off the t—extending from Ireland's Eye to Bray Head, and as far off as the Kish and Bray Banks, the deepest parts dredged being Bray Head in twenty-six to twenty-seven fathoms. We are also bted to Mr. Stephen Voysey, of "Blanna" fishing smack, for six herings taken off Mourne Mountains, off Howth, and off the Isle of 1. The Foraminifera which we have already met with number one-dred and twenty-four species and varieties, or about two-thirds of British forms. Twelve of these are additions to the Irish Fauna, (*Nodosaria hispida*) is new to Britain, and two (*Lagena curvilineata* *Nonionina pauperata*) are new to science. The only other locality Britain which has yielded so large a number of Rhizopoda is the uary of the Dee, a spot which has been most carefully examined Mr. Siddall and Mrs. Shone, and where even a still greater number orms have been found. When we consider the short space of time ady spent in the examination of this part of our coast, our results most encouraging, and leave little doubt that a renewed search ld still further increase the numbers, and lead to the discovery of r rare forms.

LIST OF FORAMINIFERA.

USPIRA, Schultze.

foliacea, Phillippi. Very rare.
involvens, Reuss. Rare.

CULINA, D'Orb.

ringens, Lamk. Frequent.
depressa, D'Orb. Frequent.
elongata, D'Orb. Very rare.

continued.

curvilineata, nov. sp. Very rare.
gracilis, Will. Very rare.
striato-punctata, P. & J. Very rare.
semistriata, Will. Common.
aspera, Reuss. Very rare.
hispida, Reuss. Very rare.
caudata, D'Orb. Frequent.
marginata, W. & J. Rare.
 var. D'Orbignyana, Sequenza. Common.
 var. trigono-marginata, P. & J. Very rare.
 var. quadrata, Will. Very rare.
ornata, Will. Very rare.
 var. trigono-ornata, Siddall. Very rare.
lucida, Will. Common.
 var. (trigono-) oblonga, Sequenza. Very rare.
lagenoides, Will. Very rare.
squamosa, Montagu. Very common.
hexagona, Will. Frequent.

LINGULINA, D'Orb.

carinata, D'Orb. Very rare; a single specimen only.

NODOSARIA, Lamk.

raphanus, Linn. Very rare; a single specimen only.
scalaris, Batsch. Rare.
pyrula, D'Orb. and dentaline variety. Very rare.
hispida, D'Orb. Very rare; a single specimen only. Ne
 Britain.

DENTALINA, D'Orb. Rare.

communis, D'Orb. Rare.
consobrina, D'Orb. Very rare.

VAGINULINA, D'Orb.

legumen, Linn. Very rare.
linearis, Montagu. Very rare.

MARGINULINA, D'Orb.

glabra, D'Orb. Very rare.

CRISTELLARIA, Lamk.

rotulata, Lamk. Very rare.
vortex, F. & M. Very rare; a single specimen only
 Ireland's Eye, seven to nine fathoms.
cultrata, Montfort. Very rare; a single specimen only
 Ireland's Eye, seven to nine fathoms.
crepidula, F. & M. Very rare.

MORPHINA, D'Orb.

lactea, W. & J. Rare.
gibba, D'Orb. and var. æqualis, D'Orb. Common.
oblonga, Will. Rare.
compressa, D'Orb. Frequent.
fusiformis, Rœmer. Very rare.
cylindroides, Rœmer. Very rare.
concava, Will. Very rare.

ERINA, D'Orb.

angulosa, Will. Rare.

LLINA, Ehrenb.

vivipara, Ehrenb. Very r
tuberculata, Brady. Very off Ireland's
Eye, seven to nine fa

LINA, D'Orb.

universa, D'Orb. Very r

IGERINA, D'Orb.

bulloides, D'Orb. Frequ
inflata, D'Orb. Very rar

ENIA, P. & J.

sphæroides, D'Orb. Very rare; a single specimen only; off Howth, eleven fathoms.

BINA, P. & J.

rosacea, D'Orb. Common.
globularis, D'Orb. Very common.
Bertheloti, D'Orb. Very rare.
Wrightii, Brady. Very rare.

ORBULINA, D'Orb.

Mediterraneensis, D'Orb. Frequent.

CATULINA, D'Orb.

lobulata, Walker. Very common.

ULINA, P. & J.

auricula, F. & M. Very rare.
Karsteni, Reuss. Very rare.

Anal. 1. Gibbsite, from Richmond, Massachusetts—

·309 gram	lost	·003 gram H_2O in vacuo	=	0·97%
·309 ,,	,,	·001 at 100° C.	=	0·30%
·309 ,,	,,	nothing in water-oven		
·309 ,,	,,	·106 on ignition	=	34·30%.

Anal. 2. Gibbsite, from Villa Rica, Brazil—

·213 gram	lost	·002 gram H_2O in vacuo	=	0·93%
·213 ,,	,,	nothing up to 100 C.		
·213 ,,	,,	·069 gram on ignition		32·39%.

Both the specimens were of great purity, neither containing any silica, and a mere trace of phosphate being present in No. 2 only; this latter specimen was uniformly crystalline. The mean percentage of combined water, corrected for accidental moisture, amounted to 33·73—a figure closely agreeing with the number demanded by theory, namely, 34·48. This percentage of water is that required by the formula Al_2O_3, $3H_2O = Al_2\ H_6\ O_6$, the normal aluminium hydrate.

§ IV. *Variscite.*—We have now to consider the mode in which the water present in such of the native aluminium phosphates as are free from excess of base is held. For the solution of this problem it might have been thought that several native species would have served. But there proved to be but one mineral of sufficiently definite character, obtainable for this purpose in adequate quantity: this was *variscite*, a phosphate found at Messbach, Saxon Voigtland, and described by Breithaupt in 1837. It is clearly identical with the callainite of Damour, a mineral the *provenance* of which is unknown, but of which some polished beads and ornaments were found in a Celtic grave at Morbihan. The two other normal aluminium phosphates which have been described are the gibbsite of Hermann, and zepharovichite. Of the latter, I have been unable to obtain an authentic or adequate supply: of the former mineral nothing definite is known; its separate existence is perhaps doubtful. Thus my work has been perforce limited to variscite.

On submitting a carefully selected and prepared specimen of variscite to the desiccating processes before mentioned, it was evident that the water in this mineral was held far more loosely than that in calaite, or true turquoise, and in wavellite. The analytical results are here given:—

Variscite[1] (spec. grav. 2·24), from Messbach.

Anal. 3.	·119 gram	gave	·084 gram	$Mg_2P_2O_7$	=	45·15% P_2O_5
,,	,,	,,	·0388 ,,	Al_2O_3	=	32·60% Al_2O_3
Anal. 4.	·371 ,,	lost	·01 ,,	H_2O in vacuo	=	2·64%
,,	,,	,,	·08 ,,	H_2O at 100°	=	21·11
,,	,,	,,	·004 ,,	H_2O on ignition	=	1·08
Anal. 5.	·32 ,,	,,	·0795 ,,	H_2O on ignition	=	24·84
,,	,,	gave	·005 ,,	Fe_2O_3	=	1·56.

[1] Containing some Fe_2O_3; *vide* analysis 5.

An inspection of these figures shows that variscite loses nearly all its water at 100° C., but practically none, or at least not a whole molecule, in vacuo over sulphuric acid. If we reject, as non-essential, the 1·64% H_2O lost in vacuo, then the percentages deduced from the analyses given above will stand thus:—

	Experiment.	Theory. $Al_2O_3, P_2O_5, 4aq.$
Alumina, ...	31·04	32·45
Ferric Oxide, ...	1·56	—
Phosphorus Pentoxide, . .	45·15	44·82
Water, ...	23·27	22·73

§ V. According then to the above-given analyses of normal native hydrate and phosphate of aluminium, the former loses no water at 100°, the latter all. The results of R. Helmhacker's experiments with the supposed variscite of Freienstein, near Leoben,[2] are not in accordance with this view so far as regards the normal phosphate. He obtained 16·11% water lost at 100°, and 17·57% on ignition. The alumina amounted to 34·46%, while the phosphorus pentoxide was only 25·69. These figures are allowed by Helmhacker to point to an admixture of diaspore with his variscite in the ratio of 4 : 5; now, as diaspore resembles gibbsite in its total retention of water at 100° C., we possess, in these apparently anomalous results, an actual confirmation of the conclusion to which my own experiments had led. Possibly Helmhacker's 100° C. may have been the conventional expression for the temperature of the water-oven, which would fall considerably short of that figure. With an air-oven at 100° C. his mineral would probably have lost more than 16·11%.

§ VI. Here perhaps it may be well to introduce the analysis of a mineral from Langen Striegis which, though in physical characters resembling the peganite of Breithaupt, yet gave very different results from those obtained with that mineral (or what we must assume to have been that mineral) in the hands of Hermann. He obtained numbers corresponding to those of a member of the calaite group ($2Al_2O_3, P_2O_5, 6H_2O$); but I find that my specimen is chemically and physically much nearer variscite than calaite. Anyhow, the assumption that this mineral is nothing but wavellite cannot be maintained. If not a perfectly definite species, yet its behaviour when heated to 100° marks it out from wavellite and from nearly all the other phos-

[2] Tchermak's *Min. & Petr. Mitth.* ii., p. 229, *et seq.*

minium. While in vacuo it loses nothing, at 100°C. (in , all the water in the mineral is disengaged. In the water-ıge is incomplete, for at 94°, the maximum temperature y water-oven, rather less than half the total water was may be noted that the curious pink tint which peganite heated in a bulb-tube was acquired in the air-oven at ; in the water-oven at a temperature only a few degrees

sis of a sample of this so-called peganite from Striegis, wing results :—

anal. 6. ·374 gram lost nothing in vacuo, but lost
·035 ,, H_2O in water oven, and
·047 ,, H_2O in air bath at 100°, and gave
·005 ,, SiO_2
·133 ,, Al_2O_3 and
·243 ,, $Mg_2P_2O_7$.

inslated into percentages and compared with the numbers de-d by the nearest formula, the results are here shown :—

	Experiment.	Theory. $7Al_2O_3, 6P_2O_5, 24H_2O$.
Alumina, ...	35·30	35·91
Phosphorus Pentoxide . .	41·56	42·53
Water, ...	21·92	21·56
Silica, ...	1·33	—
	100·11	100·00

When the correction for intruding silica is made, the correspondence between experiment and theory becomes quite satisfactory. Still it would scarcely be justifiable to accord specific rank to this mineral on the strength of a single set of numbers, and I should prefer to regard the specimen analyzed as variscite slightly admixed with a more basic aluminium phosphate.

§ VII. It is, on the whole, evident, from the analyses of gibbsite, variscite, and peganite, which I have now given and discussed, that any native basic hydrate of aluminium, if it were made up, say, of one molecule of the normal native hydrate simply associated with one molecule of the normal native phosphate, might be expected to lose, when heated to 100°, *all* the water attached to the latter compound, and *none* of that belonging to the former.

nothing but wavellite; another is very nearly related to variscite, if it be not identical with it.[5] The peganite of Arkansas, according to A. H. Chester,[6] is also identical with variscite. But there is a third mineral known as peganite found also at Striegis in Saxony; this is very near wavellite, but contains less water. What is probably the same mineral from Nobrya[7] in Portugal has been analyzed by Lichtenberger and Frenzel. As to fischerite, I have not been able to secure an authentic specimen sufficiently ample for analysis.

§ X. The next group of native aluminium phosphates may now be discussed. Its best known member is wavellite, to which the formula

$$2Al_2P_2O_8,\ Al_2H_6O_6,\ 9\ aq$$

is usually assigned. But in spite of the very numerous analyses of wavellites from different localities which have been made, the formula for this species cannot be said to have been ascertained. Two circumstances make it doubtful. Like many other fibrous minerals, wavellite always retains, under ordinary atmospheric conditions of barometric pressure, moisture, and temperature, about two per cent. of moisture removable in vacuo, or in dry air, or by a slight increase of temperature; so the question arises "Is this water essential or accidental?" Doubtless many hydrated minerals, when removed from the natural conditions under which they were formed, lose essential or constitutional water very readily, but in such cases the percentage of loss is generally much larger than two. The second circumstance which interferes with the exact determination of the combined water in wavellite is the presence of fluorine in this mineral. This element, which probably occurs to the extent of two per cent., must be regarded as an acid element, replacing either the phosphoric constituent or oxygen. If so, it will lower the proportion of phosphorus pentoxide found, and raise that of the water as determined by loss. I have considered this question in a previous research,[8] and shown that a formula with $11H_2O$ has much to recommend it. It may be added that vacuum-dried wavellite loses no water at 100° C., but 22% at 200° C., and 4% at a low red heat. And if those published analyses of wavellite in which the fluorine has been determined be studied, it will be seen that the water is lower than that commonly assigned to this mineral. But, after all, it is not improbable that we group under wavellite several minerals differing from each other by 1 aq. Possibly there are four such members of the wavellite group:—

1. *Planerite*, ... $3Al_2O_3,\ 2P_2O_5,\ 9aq.$
2. *Coeruleolactite*, . . $3Al_2O_3,\ 2P_2O_5,\ 10aq.$
3. *Wavellite*, ... $3Al_2O_3,\ 2P_2O_5,\ 11aq.$
4. *Striegisane*, . . . $3Al_2O_3,\ 2P_2O_5,\ 12aq.$

Of Coeruleolactite I shall have something to say further on, but it

[5] See § VI of this Report.
[6] Jahr. Min., 1872, 819.
[7] An analysis is given in § XII.
[8] *Jour. Chem. Soc.*, Feb., 1873.

may be useful to give here some additional evidence as to the existence of the fourth member of this group. Its formula is that commonly given to wavellite, but may perhaps more properly belong to the Striegisane of Breithaupt.

§ XI. *Striegisane.*—It was very difficult to select for analysis sufficient of this mineral without including some small specks of the slaty gangue. But as the weak acid used to dissolve the phosphate may be assumed to have been practically without solvent action on the gangue, the errors due to traces of the latter may be eliminated by recalculating the percentages after deducting the insoluble silicious residue. The results of my analysis are here given:—

Anal. 7.		·443	gram	striegisane in vacuo over H_2SO_4
	lost	·0082	,,	H_2O = 81·5%
	,,	·1188	,,	H_2O on ignition = 26·81%
	gave	·018	,,	insoluable matter = 4·06%.
Anal. 8.		·2215	,,	striegisane
	gave	·075	,,	Al_2O_3 = 33·86%
	,,	·002	,,	Fe_2O_3 = ·90%
	,,	·114	,,	$Mg_2P_2O_7$ = 32·90% P_2O_5.

These percentages, after deduction of gangue, become—

H_2O	lost in vacuo	1·92%
H_2O	,, on ignition	27·94%
Fe_2O_3	,, ,,	·93%
Al_2O_3	,, ,,	35·29%
P_2O_5	,, ,,	34·31%
		100·39.%

The above 27·94% water lost on ignition really includes some fluorine; how much, the scarcity of the mineral prevented me from determining. If it did not exceed two per cent., then this specimen of striegisane, though clearly related to wavellite, may perhaps serve to strengthen the view that two minerals, differing merely by 1 aq., have hitherto been included under that species. The 2% water lost in vacuo and the absence of any further change at 100° are characters of wavellite to which species Erdmann[9] long since relegated Breithaupt's striegisane. Possibly the kalk-wavellite of Kosmann[10] may belong here. At all events I find in it a mere trace of lime, and a rather high percentage of water retained at 100°.

§ XII. *Peganite, &c.*—Amongst the numerous minerals or mineral varieties which have been "split" into species by some mineralogists, and by others "lumped" under wavellite, there is one which has been found at Nobrya in Portugal, and which very closely resembles some specimens of peganite. In looking over my Striegis phosphates I noticed a specimen which seemed to belong here. The amount

[9] Schw. J. lxix., 154.

[10] L. G. Ges. xxi., 795 (1869).

available for analysis was not large, but the following res
obtained with a quantity of material sufficient for an accura
sis: it should be said that ·011 gram silica has been deduc
the amount taken for analysis:—

Anal. 9.	·4085	gram in vacuo over sulphuric acid		
	lost ·0125	,,	H_2O	= 3·06%
	,, ·0545	,,	H_2O in water-oven	= 13·34%
	,, ·035°	,,	H_2O on ignition	= 8·56%
	gave ·164	,,	Al_2O_3	= 40·12%
	,, ·225	,,	$Mg_2P_2O_7$	= 35·23% I

Now these results at the first glance might be taken to
wavellite formula, such as $3Al_2O_3$, $2P_2O_5$, 11 aq., which
almost precisely the percentage of water here given, and r
percentages of Al_2O_3 and P_2O_5. But the very large loss
suffered by this Striegis mineral in the water-oven separate
the species wavellite at once. And if we consider the dif
avoiding an excess of Al_2O_3 in an analysis, and the liability
as water the hydrofluoric acid which escapes on strongly
phosphate of this group, I think it may be concluded tha
perimental percentages of alumina and water are both above
while the phosphorus pentoxide should be supplemented, in
weighing the analytical results, by a small addition corresp
the lost fluorine. From these considerations it is clear that
men now under discussion differs decidedly from wavellite in
hold of most of the water present, however near it may be i
centage composition. But there is reason to think that th
under discussion, as well as wavellite itself, retains at ordi
peratures 2 or 3% of interstitial or mechanical moisture,
both cases is easily removed in vacuo over sulphuric acid. R
ing the analytical results on this assumption, but without ma
of the other suggested corrections, we reach the following
ages:—

	Experiment.	Theory.
Alumina, ...	41·41	39·83
Phosphorus Pentoxide, . .	36·34	36·79
Water, ...	22·60	23·32
	100·35	100·00

The theoretical numbers here given are those required
formula $3Al_2O_3$, $2P_2O_5$, 10 aq. If the excess in the analyti

centages were simply thrown on the alumina, the discrepancy between experiment and theory would not be unreasonably large, particularly as the alumina did contain traces of ferric oxide. The present analysis is alluded to in my classification table (§ XV.) under the signature "Coeruleolactite," for the published analyses of that mineral (by Petersen and by Genth) from two localities, Rindsberg, Nassau, and Chester Co., Pennsylvania, carefully studied, lead to the formula $3Al_2O_3$, $2P_2O_5$, 10 aq. above given. I do not, however, find that any experiments have been made, by the analysts just named, to determine the tenacity with which the water in coeruleolactite is held.

§ XIII. *Coeruleolactite.*—It seemed important to secure some information on this point in order to learn what warrant there might be for including these four minerals found respectively at Striegis, at Nobrya, at Rindsberg, and in Chester Co. Pa., under the same specific name. With this object in view, I made the following trials with a picked specimen of coeruleolactite from the last-named locality: the percentages have been recalculated after the deduction of the undissolved silica :—

Anal. 10.	·1235 gram lost	in vacuo	·004 gram	H_2O = 3·24%
	·1235 ,, ,,	in water-oven	·003 ,,	H_2O = 2·43%
	·1235 ,, ,,	at 100°	·007 ,,	H_2O = 5·67%
	·1235 ,, ,,	on ignition	·018 ,,	H_2O = 14.57%.

It is worth while recalculating these results once more after deducting the small percentage of water lost in vacuo. Then we find that the vacuum-dried mineral lost 8·37% H_2O at 100°C. in the air-oven; and 15·06% more on ignition. This result confirms my conclusions as to the position of the Striegis mineral referred to in § XII., and tends to show that the group of minerals under discussion may be referable to a single species, differing from wavellite not merely in a lower percentage of water but also in constitution. It is true that the analytical results, so far as the percentages of water lost at different temperatures are concerned, are not alike in the two minerals analyzed, but in both cases we have a notable proportion of water lost and a notable proportion retained at 100°. This suffices to suggest for these minerals a constitution in which both the normal hydrate and the normal phosphate bear parts, being associated in such a way as to retain in a measure their ordinary relations to their own combined water.

§ XIV. *Evansite.*—This species, from Zsetczik in Hungary, is at once the most basic and the most highly hydrated of all the native aluminium phosphates. It occurs in colourless and nearly transparent nodular concretions, and was formerely mistaken for allophane. The late David Forbes analyzed[11] it with such care that nothing remained to be accomplished, save to ascertain the condition in which the water exists

[11] *Philosophical Magazine*, November, 1864.

in the mineral. No doubt can be entertained of the title of evansite to specific rank, although its claim has not been duly recognized in mineralogical text-books.[12] I give here the mean percentages obtained by Forbes from his three analyses, and the corresponding numbers demanded by the formula he adopted:—

	Experiment.	Theory, $3Al_2O_3, P_2O_5, 18H_2O$.
Alumina, ...	39·31	39·78
Phosphorus Pentoxide, . .	19·05	18·35
Water, ...	39·95	41·87
Silica, ...	1·41	—
Loss, ...	·28	—
	100·00	100·00

On placing the finely-powdered mineral over sulphuric acid in vacuo it lost little more than traces of moisture: but at 100°, or rather in the water-oven, a very different result ensued. Here are the figures:—

Anal. 11. ·37 gram evansite lost in vacuo in 36 hours
·004 ,, H_2O. At 100° it sustained a further loss of
·0795 ,, H_2O. On moderate ignition the remainder,
·0685 ,, H_2O, was evolved.

The percentages of water to which the above results correspond are as follow:—

Loosely combined water, lost at 100°	22·56%
Water, lost on ignition, ...	18·51%
Total water, ...	41·07%

Now if evansite contains $18H_2O$, the loss of

10 H_2O corresponds to	23·26%
8 H_2O ,, ,,	18·61%
	41·87%

These numbers leave no doubt as to the peculiar position occupied by evansite amongst the aluminium phosphates. In accordance with the

[12] Rammelsberg's *Mineral-Chemie*, 2nd ed., vol. ii., p. 320.

system deduced from the study of other members of this series, we may arrange its formula thus—

$$3Al_2O_3,\ P_2O_5,\ 8H_2O + 10\ aq.$$

Here the 10 aq. represent those molecules of water which are disengaged in the water-oven. How the 8 H_2O are combined with the Al_2O_3 and the P_2O_5 has not been ascertained, but this may be said, that the fixity of this water at or near 100° forbids the assumption that in evansite we have an association of $Al_2P_2O_8 2$ aq. with $2\,Al_2H_6O_6$.

If there be no doubt that the entire molecule of evansite contains not less than 18 of H_2O, the relation of liskeardite[13] to this species will have to be reconsidered. If that mineral be "an arsenical evansite" it should contain 2 molecules of water more than have been assigned to it. Its formula has been expressed hitherto thus—

$$3\,R_2O_3,\ As_2O_5 + 16\,H_2O,$$

where R_2O_3 represents alumina with some ferric oxide.

§ XV. The following Table will prove useful in comparing the experimental numbers given in this Report with those required by theory.

PROPOSED CLASSIFICATION OF ALUMINIUM PHOSPHATES.

SPECIES.	FORMULA.	Theoretical Percentages of		
		Al_2O_3 (102·6).	P_2O_5 (142).	H_2O (18)
	GROUP I.			
?	Al_2O_3, P_2O_5, 2 aq.	36·56	50·61	12·83
VARISCITE, . . .	Al_2O_3, P_2O_5, 4 aq.	32·40	44·85	22·74
ZEPHAROVICHITE, .	Al_2O_3, P_2O_5, 6 aq.	29·09	40·27	30·63
?	Al_2O_3, P_2O_5, 8 aq.	26·40	36·54	37·05
	GROUP II.			
COERULEOLACTITE, .	$3Al_2O_3$, $2P_2O_5$, 10 aq.	39·83	36·79	23·32
? WAVELLITE, . . .	$3Al_2O_3$, $2P_2O_5$, 11 aq.	38·97	35·95	25·07
? STRIEGISANE, . .	$3Al_2O_3$, $2P_2O_5$, 12 aq.	38·10	35·16	26·74

[13] N. S. Maskelyne, *Nature*, August 16th, 1878.

CLASSIFICATION OF ALUMINIUM PHOSPHATES—*continued.*

Species.	Formula.	Theoretical Percentages of		
		Al_2O_3 (102·6).	P_2O_5 (142).	H_2O (18).
	GROUP III.			
CALAITE, . . .	$2Al_2O_3$, P_2O_5, 5 aq.	46·93	32·48	20·57
PEGANITE, . . .	$2Al_2O_3$, P_2O_5, 6 aq.	45·08	31·19	23·72
?	$2Al_2O_3$, P_2O_5, 7 aq.	43·36	30·01	26·63
FISCHERITE, . . .	$2Al_2O_3$, P_2O_5, 8 aq.	41·77	28·91	29·31
GROUP IV.				
EVANSITE, . . .	$3Al_2O_3$, P_2O_5, 18 aq.	39·78	18·35	41·87

§ XVI. In concluding this Report, it is my agreeable duty to thank the Royal Irish Academy for the liberal grant which enabled me to secure the material upon which I have worked. And I cannot refrain from naming in this place the generous gift made to me by Mr. Henry Willett, F.G.S., of Brighton. He learnt that a large and efficient air-pump was necessary for the proper carrying out of the drying in vacuo of the several mineral species analyzed during this inquiry. Mr. Willett gave me for this purpose one of Bianchi's magnificent air-pumps, at a cost of something like fifty pounds.

XVII.—ON A NEW AND EXPEDITIOUS METHOD FOR THE DETERMINA-TION OF THE NITRITES, UNDER DIFFERENT CIRCUMSTANCES. By EDMUND W. DAVY, A.M., M.D., M.R.I.A., Professor of Forensic Medicine, Royal College of Surgeons, Ireland, &c.

[Read, April 24, 1882.]

the existence of Nitrites and Nitrates in different natural waters been regarded (under certain circumstances) as affording evidence revious sewage contamination, the determination of the presence bsence of such compounds, and their quantitative estimation when ent, in the waters employed for domestic purposes, may be a mattter uch importance in a hygienic point of view; and though we have e delicate tests for the detection in such of the presence both of ites and nitrates, as well as different methods for their conjoint ntitative determination, there is no very simple or expeditious hod for the separate estimation of nitrites in waters, which may etimes be required, if we except that not long since proposed by riess, which method I shall presently describe, and compare with one I have myself devised, and which I shall now lay before the demy.

n making lately some experiments on certain nitrites, I observed action, which, as far as I am aware, has not hitherto been de-ed; and this being one of extreme delicacy, I have founded on it w method not only for the detection of the presence, but likewise he quantitative determination of the nitrites under different cir-tances, but especially in the case of natural waters, for which it culiarly suitable. The reaction referred to is that of nitrous or of a soluble nitrite, on the well-known substance, gallic acid; when an aqueous solution of that latter acid is brought in contact a soluble nitrite, the mixture, unless the amount of the latter nt be very small, will soon acquire a yellow or yellowish-brown which will increase in depth up to a certain point, after which olour remains permanent, whilst, at the same time, minute les of gas make their appearance in the mixture. If, however, antity of nitrate present be exceedingly small, it will require l hours, or even some days, to complete the reaction at the ordi-emperature. By the application, however, of heat,[1] and bringing ixture to the boiling point, even in the case of the most dilute ons, the reaction will be completed in a few moments. This de-ment of colour under the circumstances stated is evidently due oxidation of the gallic acid, at the expense of the nitrous acid,

[1] he continued application of heat has the effect of slightly diminishing the f colour developed in this reaction.

whereby the compound known under the name of tanno-melanic acid seems to be formed, whilst nitric oxide and carbonic acid gases are evolved. The following equation represents the changes which occur in the reaction:—

$$\underset{\text{Gallic Acid.}}{C_7H_6O_5} + \underset{\text{Nitrous Acid.}}{2HNO_2} = \underset{\text{Tanno-Melanic Acid.}}{C_6H_4O_3} + \underset{\text{Carbonic Acid.}}{CO_2} + \underset{\text{Nitric Oxide.}}{2NO} + \underset{\text{Water.}}{2H_2O}.$$

These changes, with the development of colour, take place in neutral as well as in acid solutions, but more readily in the latter, and when they are heated, than at the ordinary temperature, as already observed. The colouring principle which is so produced seems to be the same substance that is formed by the gradual oxidation of gallic acid in aqueous solution by exposure to the air; or when this takes place more rapidly, by the solution being rendered alkaline by the addition of one of the alkalies before exposing it to its influence. The colouring matter so formed is unaffected by diluted acids—at least diluted sulphuric, nitric, and hydrochloric acids had no apparent effect on it; and the organic acids, acetic, oxalic, and tartaric, even in a concentrated condition, did not seem to produce any change. It is also very permanent, and does not appear to be affected by exposure to air and light, even after being a long time subjected to their influence.

The depth or intensity of the colour produced being in direct proportion to the amount of nitrite reacting on the gallic acid, a ready means is afforded for the quantitative determination of the nitrites. Thus, if a standard solution be prepared, containing a known quantity of nitrite, and if a given amount of water or solution under examination yielded with gallic acid a certain shade or depth of colour, and if the same bulk of the standard solution, or of a mixture of it with distilled water in known proportion, developed the same tint, the former would be considered to contain the same amount of nitrite as the latter, and by thus comparing the tints produced by the waters under examination with those caused by solutions containing known quantities of nitrite, the quantitative estimation of such may be quickly accomplished, just as in Nessler's process (now so much employed by chemists) the determination of ammonia is so readily effected. Indeed the colour which is developed by the action of the nitrites on gallic acid most closely resembles that produced by ammonia on Nessler's reagent. The process, too, is conducted pretty much in the same way, except that we have a standard solution of an alkaline nitrite, instead of one of ammonia; and the test reagent is one containing gallic acid, instead of Nessler's solution; and finally, that the water or mixture, after the addition of the gallic acid solution, and a few drops of either sulphuric or hydrochloric acid, is heated to boiling in a test tube and allowed to cool; after which it is placed in a cylindrical flat-bottomed glass, to compare more accurately the degree of colour produced by the water under examination with that containing some known quantity of nitrite.

The gallic acid solution which I have employed for the determination of nitrites is a strong or saturated aqueous one, which, if not colourless, can be easily made so by boiling it for a few minutes with animal charcoal, filtering the mixture whilst still warm, and then adding immediately to the filtrate sufficient sulphuric or hydrochloric acid to render it strongly acid, which addition I have found prevents, to a great extent, the tendency of aqueous solutions of gallic acid to become of a yellow or brownish tint on keeping, which well-known property is due, as already observed, to the tendency of that acid to oxidize under such circumstances; but by the addition of the acids stated, I have kept solutions of gallic acid, which were even exposed to the air in open vessels, for over two months without undergoing any change in colour.

As to the standard alkaline nitrite solution, it may be readily prepared by decomposing a hot aqueous solution of silver nitrite with potassium or sodium chloride, and after the subsidence of the silver chloride formed, diluting the solution to the required amount. The one I employed was made, as Dr. Frankland directs, in his "Water Analysis," for the preparation of the standard alkaline nitrite solution to be employed in Griess's method for the determination of nitrites, which is prepared as follows:—0.406 gram of pure silver nitrite is dissolved in boiling distilled water, and pure potassium or sodium chloride added, till no more silver chloride is precipitated. The solution is made up to one litre, and the silver chloride being allowed to settle, 100 c.c. of the clear solution is made up to one litre, of which 1 c.c. is equivalent, as he says, to 0.01 m.gram of nitrous anhydride (N_2O_3); and he further adds, that this solution should be kept in closely-stopped bottles, quite full. A solution at least double this strength will, however, be found more convenient for my test. I may also observe that I have likewise used a standard solution made by taking the commercial potassium nitrite and boiling it along with alcohol, which will dissolve out the potassium nitrite, leaving undissolved the nitrate and other impurities; and this alcoholic solution, on evaporation and drying the residue, will furnish the nitrite suitable for this purpose.

In using this test a convenient quantity of water to employ is 25 c.c., which can be easily heated in a test tube of somewhat larger capacity, along with 1 or 2 c.c. of the gallic solution, and a few drops of sulphuric or hydrochloric acid, and, when the mixture has cooled, transferring it to a flat-bottomed cylindrical glass, where the depth of colour can be more readily determined, and compared with that yielded by equal bulks of different mixtures of the standard solution with distilled water. But where the amount of nitrite is very minute, it will perhaps be better to use at least 50 c.c. of the water under examination. I should observe that the nitrates do not produce the reaction described with gallic acid, and, unless they are present in large quantity, do not affect the test; and that it (the reaction with the nitrites) appears to be uninfluenced by the presence of the different saline and

earthy salts that occur in natural waters, as well as by the organic matters that may be there occasionally. It might be naturally supposed that soluble salts of iron (which are sometimes present to some extent in certain waters), producing as they do the well-known black or ink-like reaction with gallic acid, would preclude its employment as a means of estimating nitrites, where the former salts were present; but this is not the case; for the iron may be separated by the addition of ammonia and filtration, after which I have found that the filtrate, having been acidified, may be treated with gallic acid, for the estimation of nitrites. It appears, therefore, that none of the substances which would be likely to occur in natural waters interfere with the employment of this test.

As to what may be the exact limits of its indications, I have not yet been able to determine; but I have readily detected, by its use, an amount of nitrite in water equivalent to one part of nitrous acid in about twenty millions parts of water.

I have made a number of comparative experiments with this test of mine and those hitherto proposed for nitrites, but chiefly with that of P. Griess, already referred to, as Dr. Frankland (who is one of the first chemists of the day) has stated in his "Water Analysis," that it is the only trustworthy means we have for the estimation of nitrites.

This test, I may briefly say, depends on the reaction of nitrous acid on metaphenylene diamine, or meta-diamido-benzol, a derivative of benzol, whereby an orange-coloured compound is produced, by the oxidation of this complex basic substance. This reaction is one of extreme delicacy, and the test is carried out pretty much in the same manner as the well-known Nessler's method for the determination of ammonia; or of mine, just described, for that of nitrites; the depth of colour produced by the test solution, with the water under examination, being compared with that of one containing a known quantity of nitrite; the details, however, of the method will be found fully stated in Dr. Frankland's "Water Analysis."

From several comparative experiments I have made with Griess's method and that of my own, I have come to the conclusion that the latter is almost, if not quite, as delicate a test for the nitrites as the former. I have, however, observed this difference between them, that when the proportion of nitrites present was considerable, that then Griess's test gave a more decided reaction, or that the colour produced was of greater intensity than in the case of the gallic acid test; but that when the amount of nitrite was exceedingly minute, that then there was but little or no difference in the delicacy of their indications. In some other respects, however, the test which I have proposed possesses advantages over that of Griess; thus the metaphenylene diamine is at present a compound very difficult to be procured; so much so that though I applied twice, lately, to one of the best known firms in London for the manufacture of chemicals (Messrs. Hopkin & Williams), they were unable to procure me a little of that substance; and that which I operated on was kindly given to me by my friend

. Tichborne, who procured it direct from Berlin. On the other ıd, the reagent used in my test may be got for a few pence at r druggist's shop: again, Griess's test solution will not keep, as ıuickly acquires the same colouration that is produced by the reacı of nitrous acid or a nitrite on it, even when it is kept in closely-ppered bottles; and therefore requires to be freshly made and ·ated almost every time it is employed; whereas the gallic acid soluı which I have recommended will, I find, keep for a very consiable time without apparently undergoing any alteration requiring fresh titration, which is an important advantage. In conclusion, I y add, that whatever may be the comparative merits of the two :s contrasted, I have but little doubt that the one I have proposed l be found to be a useful and ex both the quative and quantitative determin under different :umstances.

LXXVIII.—On the Jointing of Rocks in Relation to Engineering, especially the Tunnelling of the Strait of Dover. By Professor William King, D. Sc.

[Read, 24th April, 1882.]

For some years past having been at different times engaged in studying the jointed structure of rocks,[1] I may lay some claim to taking a part in the discussion of a question in Engineering which public enterprise has lately elevated to a subject of international importance.

But before proceeding further, I may be allowed to make a few remarks on some points introductory to the subject in hand.

Already, it may be assumed, the promoters of the proposed Channel Tunnel have had their attention called to the probability that the rocks to be penetrated are so greatly affected by dislocations (faults), and fractures of the ordinary kind (that is, resulting from disruption), also to some of them possessing an openly porous character, as to prove serious detriments to the undertaking; at the same time it must be admitted that some other points of vital importance in submarine engineering of the kind appear to have been but slightly attended to, or altogether overlooked.

It is well known that the chalk and immediately associated earlier rocks, in Kent and Sussex, have been flexured into the great elliptical dome, known as the anticlinal of the weald—its longitudinal axis running generally near an east and west course. The consequence is, that the bedding of these rocks variously intersects the horizon from a low angle to a high one. Not unfrequently the partings, which define the bedding, are penetrable by water. Now, anyone who has observed the chalk, with the adjoining tertiary sands, clays, and pebble beds, in the Isle of Wight, standing in a nearly vertical position, must admit that, if such partings were at the bottom of the adjacent sea, the water would necessarily flow into them. It may be doubted that the beds of chalk or other rocks in the Channel are standing at a high angle; though in some places in the North Downs, notably St. Margaret's, Chapel Hill, they have quite a sudden dip, as mentioned by Hopkins; but there are no positive grounds for altogether excluding from the line of the tunnel beds lying at angles not exempt from danger: even if their dips be as low as 15°, which is a common figure, bedding partings, it is to be apprehended, would serve as channels for the water to penetrate to the roof, or sides of any submarine excavation.

Moreover, geologists who have examined the counties under consideration have noticed the frequent occurrence in the chalk of "sand pipes" or "gravel pipes"—large cylindrical openings in a vertical

[1] *Transactions* of the Royal Irish Academy, vol. xxv., pp. 605–662 (1875); An Old Chapter of the Geological Record (Appendix), pp. 107–119 (1881).

position, and from 40 to 80 feet deep, which, from the arrangement of their contents, have evidently been swallow holes, down which water passed into subjacent catch basins.

That similar openings are now in existence in the Channel may be considered as more than probable, seeing that "sand pipes" in Kent, as brought to light by Professor Prestwich, though at present at a considerable elevation above the sea level, must have been at the bottom of the sea during some portion of the Pliocene period, since occasionally they contain the casts and other remains of marine shells (*Terebratula grandis* and *Lutraria elliptica*) living at the time.[3]

But dislocations, fractures of disruption, inclined bedding partings, porosity and sand pipes, are not the only sources of water leakage that may be met with while excavating the Channel Tunnel: another, if a not more serious one, remains to be noticed. Rock jointing possesses characters favouring the idea of its being totally distinct from fractures of disruption—rather, a divisional structure developed by no ordinary mechanical agency; but whether this be the case or not, jointing requires to be closely considered by all parties immediately interested in carrying out the proposed undertaking to a successful issue.

The phenomenon now entered upon consists of regular and persistently parallel fissures, characteristic of both stratified and unstratified rocks: the softest shales and hardest granites are alike affected by it; and these may be of any geological age—from the Archæans up to the Eocenes. Altogether independent of bedding or stratification, the planes of jointing intersect those due to deposition, inasmuch as their usual position is oblique, or rectangular, to bedding, whether it be horizontal or inclined. Although, in general, from under an inch and often many more apart (produced by the erosive action of the water and other wasting agencies, also by stratic disturbances, making a joint resemble an ordinary disruptive fracture), the conjunctive planes or walls of a joint, in their normal or original condition, are in the closest possible contact, appearing as if they had been made by the thinnest and sharpest cutting instrument; and this is equally the case with foreign bodies, as blocks or pebbles of granite enclosed in conglomerates: the same planes have not uncommonly a surface as smooth, and occasionally as lustrous (like those of mineral cleavage), as if they had come direct from the hands of a marble polisher. The joints lie at varying distances from one another, having usually one, two, or more feet of separation; but examples are rather frequent in which they lie from an eighth to above an inch apart.

In the case of rocks lying horizontally, jointing, besides affecting a

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[3] *Quarterly Journal of the Geol. Soc.*, vol. xiv., pp. 322–335. Being present at the meeting of the Geological Society (Jan. 21, 1857), when Prof. Prestwich's Paper was read, I had an opportunity of examining the shells: the second one was stated to be a Mya-like species. From certain characters it possessed, I felt certain, as I there and then expressed, that it belonged to the still-existing species named in the text.

more or less vertical position, is found to be resolvable into two or more directional series or systems, each being distinguished by uniform parallelism, also by a definite and an independent course, of its members. It is also found that these systems are traceable, as in the limestone districts of the west of Ireland, over areas hundreds of miles in extent; often, however, more developed in some places than in others, or suddenly disappearing here, and as suddenly setting in with great force elsewhere. The remarkable approximate parallelism of these systems with the meridians and the equator seems to give propriety to one being named meridional and the other equatorial.

That jointing ought to command the closest attention of engineers engaged on subaqueous works must now be evident. The following case is added, however, to make the statement still more obvious:—

During the famine period of 1845–1848 in Ireland, the Board of Public Works commenced the construction of a canal through beds of Carboniferous limestone for drainage purposes, and the opening out of a water communication between Loughs Corrib and Mask of about four miles in length. But, on nearly completing the work, it was found that the joints, well developed in the limestone, and probably taken to be little more than superficial, carried off all the water, necessitating much additional and unexpected outlay to remedy the defect. Thus after an expenditure, as I am credibly informed, of £40,000 of public money, what was intended to be a canal turned out to be nothing else than a dry ditch; and as such it still remains—a warning to all engineers not to neglect becoming acquainted with an important geological phenomenon.

Passing to the Channel Tunnel, it is true that this scheme has nothing to do with rocks in which jointing is so well developed as in the Carboniferous limestone and other Primaries. Still, with the facts that have been before us, together with others which are yet to be noticed, I feel confident the undertaking, if it ever be properly entered upon, will develop graver difficulties than any that have been conceived by those who are actively promoting it.

For anything known to the contrary, it may be safely assumed that the rocks to be penetrated by the tunnel are the sandstones, shales, and chalk formations, included in the Cretaceous and Neocomian Systems, known to exist in the counties that have been mentioned, also in the Bas Boulonnais on the opposite seaboard of France.

As stated before, these rocks in Kent and Surrey have been thrown into flexures, running axially in a nearly east and west direction; while parallel with them is a number of dislocations or faults, and fractures. A marked feature of the flexures is, that they are broken right across by transverse gorges, seen particularly where they are in the form of ridges, through which the main rivers flow into the Thames and its estuary on the north, and into the Channel on the south.

Different hypotheses have been offered in explanation of these east to west valleys and north to south gorges: the generally accepted one ascribes them to the mechanical forces which upheaved the wealden

LXXIX.—REPORT UPON THE BOTANY OF THE MACGILLICUDDY'S REEKS, Co. KERRY. BY H. C. HART.

[Read, April 24, 1882.]

ON the 13th July, 1881, I reached Glencar Hotel, at the western extremity of the Reeks. This hotel, upon the banks of the river Caragh, is a favourite resort for anglers; and a better head-quarters for those who are in search of mountain scenery could not be selected in Ireland. From here I frequently traversed the whole length of the range, making my way into Killarney at night, and returning over the mountains in another route the following day. I spent fifteen days amongst the Reeks, and, by using cars or boats as much as possible below, I passed most of those days high up amongst the numerous alpine cliffs and ridges, or in the neighbourhood of some of the mountain tarns.

The Reeks stretch from their eastern extremity at the Gap of Dunloe to the end of the Beenbane spur, above the road from Glencar to Cloon Lake, a distance of about ten miles west from the Gap. The road from Glencar to the Gap is a northern boundary, while the Black Valley, and the valley of the Caragh define the southern limits of the range.

From Lake Auger in the Gap of Dunloe a series of precipitous bluffs carries us up at once to a height of nearly 2000 feet, which goes on increasing along a serrated ridge till it reaches 3000 feet above Lough Cummeenapeasta, about two and a-half miles west of the Gap. This ridge can be traversed then for the whole extent of the range, and forms the grandest bit of mountaineering to be met with in Ireland. For several miles it maintains an altitude of about 3000 feet, sometimes narrowing into a jagged knife-edge, and here and there descending abruptly into some of the numerous lakes nestled amongst the precipices below. Upon reaching the highest point, Carran Tuohill, 3414 feet, a northern branch extends to Beenkeragh, 3314 feet, and to Skregmore, 2790 feet; while the axis proper carries us on by Caher, 3200 feet, and Curraghmore, 2680 feet, down to the head of Cummeenacappul, where lies a gap in the ridge, which forms a connexion between Cummeenacappul on the one side and the valleys of Caragh and Cummeenduff ("Black Valley") on the other or south side. This gap is perhaps the proper western extremity of the Reeks; it lies, however, at about 1000 feet above sea level, and the Beenbane spur rises again from it to the westward, finally descending to a low level at the river Caragh. The latter appeared, therefore, the more natural boundary.

The Reeks are composed for the most part of hard green and purple grits, and sandstones of the geological formation of Old Red Sandstone age. In consequence of the firmness of these rocks, the

numerous ranges of cliffs are safe to climb amongst, and there are few points available for alpine plants that I did not succeed in examining.

There are several lakes in the Reeks; thirteen fall within the bounds above laid down. Some of these are at considerable altitudes, as Cummeenoughter (the "Devil's Looking-glass") at 2338 feet, and Cummeenapeasta at 2156 feet; while, by including Lake Acoose at 500 feet, we have means of comparison at various heights for about 2000 feet of the altitudes at which different aquatic plants can exist. All these lakes I examined; but the chief haunts of the alpine plants in the Reeks lie, as a rule, at higher altitudes than even the uppermost of these lakes. No general rule, except that of height, would guide a botanist to the rarer plants; they occur upon cliffs with various aspects, at both northern and southern sides of the chain. Absence of the direct influence of strong sunlight, with moisture, and a sufficiency of cliffs, enable alpine plants to descend to a level more than usually low, as on the cliffs above Lake Auger in the Gap of Dunloe. These latter are amongst the worst, though at the same time most attractive, cliffs, to climb throughout the Reeks. It will be found, however, that lowland plants ascend to a more considerable height upon the southern than upon the northern flanks of the range. I estimated this difference at a rough average of about 500 feet.

The most inviting ground for a botanist lies perhaps amongst the cliffs south of Lough Eagher, at the head of Cumloughra. There is, however, a high valley, or rather series of coombs, to the north of Lough Googh, which is more alpine in its botanical facies than any other point of the Reek. Most of the alpine plants of the range grow here to perfection, while numerous grottos shelter a luxuriant growth of ferns, which are, I think, inaccessible enough to be tolerably safe from the depredation of collectors. A good colony of holly fern was here discovered, while green spleenwort and brittle fern are everywhere abundant.

The variable *Draba incana* is also to be gathered here, and several saxifrages are very common. The amphitheatre of cliffs around the "Devil's Looking-glass" is attractive ground for explorations also. In the upper margin of these precipices *Aira caespitosa*, var. *alpina*, a viviparous form, not previously recorded in Ireland, but known on the Scottish Highlands, is frequent.[1] I have gathered this form also upon Baurtregaum in the Slieve Mish range, west of Tralee, at 2200 feet, and upwards. From the crest of these cliffs westward, above the "Looking-glass," the view obtained, as one looks across the lonely tarn below, through a vista opening up the Hag's Glen, and its towering precipices surrounding its two lakes, stretching far eastward amongst heights and peaks across a broad valley, to be closed up

[1] See under *Aira* at 3100 feet, *post*.

gain by the lofty summit of Cummeenapeasta against the sky, is one hich I have never seen surpassed in grandeur and beauty combined.

The highest altitude at which I observed cultivation was at about 00 feet in the Hag's Glen, and 730 feet in Cummeenacappul on its estern side. But, while the base of the chain is mountainous in aracter and undoubtedly part of the mass of mountains forming the eeks, it seems unadvisable to set an artificial downward limit to my umeration of the flora of the chain. There is so interesting a low-nd flora in Kerry, that it seemed to me quite as important to note ow these species below were checked in their distribution on its anks by a mountain chain, as to study the range of the plants nongst the mountains themselves.

I have used, in my appended catalogue, the names of places as iven in the Ordnance Map. These are very scanty, so that I have iven the summits above the Lakes Cummeenmore, 3141 feet, and ummeenapeasta, 3062 feet, the names of these lakes respectively. adopting the names to be found on the Ordnance Maps, I did what peared to be necessary for purposes of reference; but the local ames are often quite different, and frequently the names on the Map ere quite unknown in the country. One advantage the Maps of this strict possess, namely, the levels above the sea of the mountain lakes, hich are given on the Six-inch Survey. In order to show that ane-id observations are sufficiently reliable, I append a list of the heights these lakes, as estimated by me on the spot, with those recorded by e survey afterwards taken down in Dublin:—

ANEROID.			SURVEY.
Lake Googh,	1600	feet above sea level,	1590.
,, Callee,	1100	,, ,,	1095.
,, Gouragh,	1150	,, ,,	1126.
,, Curraghmore,	1000	,, ,,	1004.
,, Cummeenoughter,	2400	,, ,,	2338.
,, Cumloughra,	1550	,, ,,	1553.
,, Eighter,	1500	,, ,,	1424.
,, Acoose,	500	,, ,,	507.

The district examined yielded in all 220 species; of these the fol-wing ten alpine plants belong to Watson's Highland type:—

Draba incana.
Sedum Rhodiola.
Hieracium anglicum.
Oxyria reniformis.
Salix herbacea.
Carex rigida.
Polystichum Lonchitis.
Asplenium viride.
Isoetes lacustris.

To these may be added the following sub-species:—

Armeria alpina,
Cochlearia alpina,
Aira alpina,

and *Lycopodium alpinum*, which Mr. More informs me he has gathered upon the Reeks, but which I failed to notice.

Considering the extent of elevated cliffs, the above is a poor alpine flora. The northern or Scottish type plants are, considering the latitude, at least as well represented; these are:—

Subularia aquatica.
Saxifraga hirta.
Antennaria dioica.
Lobelia Dortmanna.
Empetrum nigrum.
Carex limosa.

As might be expected, from the western situation, several of Watson's Atlantic type plants find their way up the slopes of the Reeks, as—

Sedum anglicum.
Cotyledon umbilicus.
Carum verticillatum.
Bartsia viscosa.
Pinguicula lusitanica.
Euphorbia hyberna.
Scirpus savii.
Hymenophyllum tunbridgense.
H. Wilsoni.

The undermentioned species are peculiarly interesting as not being native in Great Britain:—

Saxifraga geum.
S. umbrosa.
S. hirsuta.
Arbutus Unedo.
Pinguicula grandiflora.
Trichomanes radicans.

The following are rare plants in Kerry, for which I discovered new localities on the Reeks:—

Thalictrum minus.
Subularia aquatica.
Elatine hexandra.
Filago minima.
Antennaria dioica.
Hieracium anglicum.
Empetrum nigrum.
Salix herbacea.
Malaxis paludosa.
Sparganium natans.
Carex limosa.
Polystichum Lonchitis.

As these are the highest mountains in Ireland, I recorded the ranges of plants with much care, and repeated corroboratory checks. I mention this lest it be thought my notice of altitudes is given too profusely.

Further, I purposely refrain from making any general statements with regard to mountain botany, or remarks of comparison with other Irish ranges, until better enabled to do so by a more complete experience.

I wish here to make a remark upon the saxifrages: Having submitted a series to Mr. Baker, of Kew, he refers all the *S.*

forms to *S. hirta*, Sm. This plant is very variable, and two well-marked forms, the typical plant occurring at eights, and usually in more alpine situations and amongst ghbours. Specimens from Baurtregaum, on the Slieve Mish Baker has called *S. affinis*, Don. It is quite indistinguish- the plant of the Reeks; but bears sometimes a close resem- *S. cæspitosa*, Linn. Unfortunately an inversion of names in my "Report[2] on the Botany of the Galtee Mountains." ere said that *S. platypetala* is the form usually met with in ossy places at low levels by streams; "while *S. hirta*, var. he finest cut form with bristle-pointed leaves, is especially stic of the bases of the loftier cliffs." These names should osed. *S. platypetala* of the Galtees, this finest leaved form, tinct in appearance, more so, I think, than any of the others; d *S. sponheimica*, Gm., by Baker, and I have only met with e Galtees.

regard to the *S. umbrosa* forms; as we travel westward *S.* omes more prevalent. On the Galtees *S. umbrosa* alone n the Reeks *S. umbrosa* is most abundant; but *S. geum* nt, while *S. hirsuta* occurs. *S. geum*, however, never any great height on the Reeks, finding its upper limit feet in Cumloughra, while *S. hirsuta* is quite lowland. lieve Mish Mountain, west of Tralee, *S. geum* prevails at , and is abundant.

GENERAL LIST OF PLANTS

on *the* MACGILLICUDDY'S REEKS, *arranged in descending order.*

SUMMIT OF CARRAN TUOHILL.

3414 feet.

xatile (Linn.)—On all the summits, and downwards.

Myrtillus (Linn.)—On all the summits, and downwards.

naritima (Willd.)—Occurs on all the highest points com- , and reaches downwards to 1900 feet on the cliffs of , S.W. from Cumloughra; and 1000 feet on the muddy of Curraghmore lake.

etosa (Linn.)—On all the summits, and downwards.

la (Linn.)—Not so common as the last; occurs again at 3070 S.W. from Lough Cummeenapeasta, and elsewhere.

ratica (Bichen.)—With the last, and on the summit above h Cummeenmore at 3070 feet; decreases at 2000 feet, and lower than 1500 feet in Cumloughra.

[2] These *Proceedings*, *antea* p. 392.

Aira flexuosa (Linn.)—Common at all heights.
Agrostis vulgaris (With.)—Common at all heights.

CARRAN TUOHILL (NORTH SIDE).

3400 feet.

Saxifraga stellaris (Linn.)—Occurs on Caher at 3100 feet, north side; reaches to 1050 feet on Bull's Mountain, and finds its lowest limit at 750 feet by the stream in Cummeenacappul.

3370 feet.

Saxifraga umbrosa (Linn.)—Universally distributed; see introductory remarks.

SUMMIT OF BEENKERAGH.

3300 to 3314 feet.

Empetrum nigrum (Linn.)—From 3000 feet to the summit; does not occur on the Carran Tuohill or Caher heights. It ranges across the Hag's Glen to Cummeenapeasta, where it is very abundant, and the neighbouring heights, finding its lowest limit at 1700 feet on the east side of the Glen. It occurs also on the Gap from the Hag's Glen to Curraghmore Lake, and at the Hag's Tooth.
Calluna vulgaris (Salisb.)—The upper part of Carran Tuohill, though containing suitable soil, appears to be above the vertical limit of this plant; it was very stunted in the present station, and at Cummeenmore (3140 feet) it was dwarfed and dead. It struggles up to 3250 feet on Carran Tuohill.
Festuca duriuscula (Linn.)—Also at 3140 feet on Cummeenmore; viviparous at 3100 feet on Caher.
Juncus squarrosus (Linn.)—Up to 3000 feet on Caher.
Carex stellulata (Good.)—3050 feet on Caher; 3000 feet down Cummeenapeasta.
Hymenophyllum Wilsoni (Hook.)—This fern is very abundant, forming carpets amongst the loose boulders on the summit of Beenkeragh; at 2900 feet on the Caher cliffs, S. W. from Cumloughra, and frequent at lower heights.

CARRAN TUOHILL (S. W. SIDE).

3230 feet.

Thymus Serpyllum (Linn.)—Very common from about 3000 feet downward, especially about Cumloughra; at 3100 feet on Beenkeragh.

3200 feet, N. W. side.

Viola sylvatica (Bab.)—Occurs up to 3100 feet on the north side of Caher.

Leontodon autumnalis (Linn.)—In small quantity at this unusual height; again at 2690 feet, S. W. side of Carran Tuohill, and 2250 feet in Cumloughra.

CLIFFS ABOVE LOUGH CUMMEENOUGHTER (THE "DEVIL'S LOOKING-GLASS") ON CARRAN TUOHILL.

3150 feet.

Saxifraga hirta (Sm.)—(var. *genuina*)—The commonest form amongst the upper cliffs, and occurring downwards as far as Lake Eighter, 1500 feet. This latter is the lower limit of all forms of the present species. See introductory remarks.

Sedum Rhodiola (D.C.)—Frequent, and occurring at 1200 feet, its lower limit on Bull's Mountain, above Lake Auger, in the Gap of Dunloe; 2900 feet on Cummeenapeasta; 2850 feet on Caher. Ceases at 1700 feet above Lough Curraghmore.

Melampyrum pratense (Linn.)—(var. *montanum*)—And at 3120 feet on the south side of Caher; at 3100 feet on Carran Tuohill and Beenkeragh, &c.

Oxyria reniformis (Hook.)—In most of the upper gullies; to 1650 feet in Cumloughra; and 1500 feet on Mount Brassel, above Lake Callee.

Cystopteris fragilis (Bernh.)—Very luxuriant above Lake Googh at about 2500 feet; and in Cumloughra at 1400 feet above Lake Curraghmore on cliffs looking south; disappears here as a mountain plant.

Lastræa Filix-mas (Presl.)—A stunted mountain form, is frequent at the head of the Hag's Glen; Caher, 2850 feet; Cumloughra, 2400 feet.

Blechnum boreale (Sw.)—Not frequent till about 2800 feet.

Asplenium viride (Huds.)—At 2850 feet above Cumloughra; lower limit at 1850 feet in Cumloughra. Remarkably luxuriant in the coombs above Lough Googh; a common plant at a sufficient height on the Reeks.

CARRAN TUOHILL (S.-W. SIDE).

3120 feet.

Potentilla Tormentilla (Schenk.)—And at 3000 feet on Caher; abundant from that height downwards.

CAHER (SOUTH SIDE.)

3120 feet.

Campanula rotundifolia (Linn.)—At 3100 feet at the head of the Hag's Glen; frequent from two to three thousand feet in Cumloughra; disappears at 1860 feet above Lough Curraghmore.

Luzula campestris (D. C.)—Again at 2850 feet, Cumloughra; not unfrequent.

Carex pilulifera (Linn.)—And at 2350 feet, Cumloughra; 800 feet in Cummeenacappul; not common.

Nardus stricta (Linn.)—Occurs also at 2690 feet on S.-W. side of Carran Tuohill; common below that.

CARRAN TUOHILL (NORTH SIDE).

3100 feet.

Cochlearia officinalis (Linn.)—Var. *alpina;* in gullies above Cummeenoughter; lower limit at Cumloughra Lake level, 1550 feet.

Aira cæspitosa (Linn.)—var. *vivipara; A. alpina* (Linn.)—This form is well marked at the present height and all around the cliffs at about 2700 to 2800 feet above Cummeenoughter to Beenkeragh; at the level of the Devil's "Looking-glass" (2350 feet) it is found in an intermediate stage, and, travelling still downwards, we find normal *A. cæspitosa* immediately below by the shores of Lough Gouragh, at 1150 feet. In A. G. More's "Recent Additions to the Flora of Ireland" he records *A. cæspitosa*, "which, except that the florets are not viviparous, Dr. Syme considers indistinguishable from the Scottish *A. alpina;* grows near the summit of Carn Tual." I found it commonly viviparous, and constantly so at its upper limit. Mr. Baker refers to it *A cæspitosa*, var. *vivipara*. It is, no doubt, identical with the Scotch plant.

RIDGE BETWEEN LAKE CURRAGHMORE AND LAKE CUMMEENAPEASTA.

3070 feet.

Luzula multiflora (Lej.)—Common downwards.

RIDGE BETWEEN CARRAN TUOHILL AND BEENKERAGH.

3050 feet.

Jasione montana (Linn.)—Becoming frequent at about 2600 feet in Cumloughra.

Carex rigida (Good)—Frequent from 2900 to 2300 feet above Cumloughra; lower limit at 2100 feet in Cumloughra.

SUMMIT ABOVE LAKE CUMMEENAPEASTA.

3050 feet.

Salix herbacea (Linn.)—At 3000 feet on the north side of Caher; plentiful on the cliffs between Caher and Cumloughra, from 2700 to 2350 feet, below which I did not meet with it. Frequent along the ridge between Cummeenapeasta and Curraghmore lakes, and on Carran Tuohill at the northern side.

Lycopodium Selago (Linn.)—Frequent to about 2300 feet; lower limit at 1850 feet above Cumloughra.

CARRAN TUOHILL (S.-W. SIDE).

3030 feet.

Anthoxanthum odoratum (Linn.)—Again at 2850 and 2450 feet in Cumloughra; and then becoming frequent.

RIDGE ABOVE CUMMEENAPEASTA LAKE.

3000 feet.

Cerastium triviale (Link.)—At 2610 feet on Caher; then frequent.

Solidago Virga-aurea (Linn.)—At 2776 feet above L. Curraghmore; frequent in Cumloughra, &c.

Lastrea dilatata (Presl.)—At 2350 feet, close to the lake, in Cummeenoughter; at 2100 feet in Cumloughra, and then becoming frequent.

2950 feet.

Ranunculus acris (Linn.)—At 2850 and 2450 feet, Cumloughra; and then frequent.

CLIFFS BETWEEN CAHER AND CUMLOUGHRA.

2940 feet.

Cardamine pratensis (Linn.)—At 2550 feet S.-W. side of Carran Tuohill, and at 2450 feet, Cumloughra.

2900 feet.

Antennaria dioica (Gœrt.)—Very rare; only a few plants noticed.

CARRAN TUOHILL (S.-W. SIDE).

2880 feet.

Euphrasia officinalis (Linn.)—And from about the same height on Caher; common.

RIDGE BETWEEN CAHER AND CARRAN TUOHILL.

2850 feet.

Asplenium Trichomanes (Linn.)—This fern is scarce at any considerable altitude in the Reeks; it is more frequent in the Gap of Dunloe on the Bull's Mountain than elsewhere.

S.-EASTERN SIDE OF CARRAN TUOHILL, ABOVE L. CURRAGHMORE.

2800 feet.

Orchis maculata (Linn.)—Not met with elsewhere at any great height.

SUMMIT N.-E. FROM L. CURRAGHMORE.

2776 feet.

Eriophorum vaginatum (Linn.)

CLIFFS S.-W. FROM CUMLOUGHRA.

2610 feet.

Angelica sylvestris (Linn.)—Afterwards not unfrequent; 2550 feet above Lough Googh.

Polypodium vulgare (Linn.)—Common below.

CARRAN TUOHILL (S.-W. SIDE).

2550 feet.

Ranunculus repens (Linn.)—Rare at great heights; 2450 feet on Caher.

Viola palustris (Linn.)—2200 feet above Lake Googh; frequent at lower levels.

Carex flava (Linn.)—Common at lower levels, from 2300 feet downwards.

CLIFFS NORTH OF LAKE GOOGH.

2550 feet.

Draba incana (Linn.)—And at 2470 to 2380 feet on cliffs looking south between Cummeenmore and the Black Valley. In two distinct gullies here, and not scarce in a limited space above L. Googh. Only occurs on the south side of the Reeks. Varies much in hairiness, incision of leaves, etc.

Cardamine hirsuta (Linn.)—Again at 1390 feet in the central gully from Cumloughra; not at greater altitudes.

Stellaria media (With.)—Not met with elsewhere at any great height; 975 feet, Beenbane.

Veronica Chamædrys (Linn.)—Again at 2470 feet on the southern side of Cummeenmore, and 1950 feet in Cumloughra.

Poa annua (Linn.)—Again at 2250 feet on the southern side of Cummeenmore, and at 2400 in Cummeenoughter.

Carex binervis (Sm.)—And at 2470 feet in Cummeenoughter; common below.

C. panicea (Linn.)—An unusual height for this sedge; 1850 feet, Cumloughra.

Polystichum Lonchitis (Roth.)—I discovered a colony of well-grown plants of the holly fern in a tolerably safe position here. I trust any future visitor will disturb it as little as I did. This, one of the rarest Irish ferns, grows also sparingly on Mangerton and Brandon in Kerry. Elsewhere in Ireland it occurs only on the Ben Bulben and Glenade ranges.

Cliffs above Cummeenoughter ("Devil's Looking-glass.")

2500 feet.

Tieracium anglicum (Fries.)—At 2080 feet, cliffs south of Cummeenmore; in Cumloughra and on Bull's Mountain in several places, and finding its lowest limit on the Bull's Mountain cliffs above Lake Auger in the gap of Dunloe at 1100 feet; not previously recorded from the Reeks.

Caher, above Cummeenacappul.

2500 feet.

rica cinerea (Linn.)—A small isolated patch of heather occurs on the southern brow of the ridge between Curraghmore and Caher; as a feature in the vegetation it ceases upwards here at 2200 feet. Ceases at 2200 feet on Cummeenmore; at 2150 feet, Bull's Mountain; at 1950 feet, Cumloughra, and at 1700 feet above L. Curraghmore.

Carran Tuohill (S.-W. Side).

2480 feet.

hrysosplenium oppositifolium (Linn.)—And at 2470 feet, south side of Cummeenmore; then frequent.

Cummeenmore, South Cliffs above Cummeenduff (Black Valley.)

2470 feet.

araxacum Dens-Leonis (Drof.)—And at 2250 feet and 1950 in the central glen from Cumloughra.

olystichum aculeatum (Roth.)—And at 900 feet in Cummeenacappul; scarce.

Carran Tuohill (S.-W. Side).

2440 feet.

olygala depressa (Wend.)—True *P. vulgaris* occurs at 2400 feet at the "Devil's Looking-glass."

Iypericum pulchrum (Linn.) Again at 2200 feet on south side of Cummeenmore Mountain.

dicularis sylvatica (Linn.) Soon becoming common.

South Side of Cummeenmore.

2380 feet.

rex pulicaris (Linn.)—Also at 1800 feet above Lough Curraghmore; rather scarce.

hinanthus crista-galli (Linn.)—And at 1500 feet, Bull's Mountain, above the Gap of Dunloe.

CUMMEENMORE, BY THE LAKE.

2350 feet.

Ranunculus Ficaria (Linn.)—And at 2250 and 1950 feet in Cumloughra.

2338 feet (Ordnance height.)

Isoetes lacustris (Linn.)—And in Lake Eighter, 1500 feet.

CLIFFS S.-W. FROM CUMLOUGHRA.

2300 feet.

Pyrus Aucuparia (Linn.)—A solitary seedling. Again at 1360 feet on Beenbane; scarce on the Reeks.

SOUTH SIDE OF CUMMEENMORE.

2300 feet.

Stellaria uliginosa (Murr.)—And at 1553 feet, level of lakes in Cumloughra; frequent below this last height.

HEAD OF CUMLOUGHRA.

2300 feet.

Athyrium Filix-fœmina (Roth.)—Not elsewhere at any considerable height.

2250 feet.

Oxalis Acetosella (Linn.)—Becoming frequent at about 1800 feet.
Digitalis purpurea (Linn.)—At the same height on the southern side of Cummeenmore; not frequent for about a thousand feet down.
Molinia cærulea (Mœnch.)—Not abundant for about seven hundred feet lower down.
Juncus conglomeratus (Linn.)—Frequent in upper valleys.

ABOVE LAKE CUMMEENMORE.

2250 feet.

Pinguicula grandiflora (Lam.)—I gathered this beautiful plant in flower at this height, and again at 1780 feet in the Hag's Glen.

SOUTH SIDE OF CUMMEENMORE MOUNTAIN.

2250 feet.

Veronica officinalis (Linn.)
Primula vulgaris (Linn.)
Several lowland plants reach an unusual height on this southern face of the Reeks above the Black Valley. Primrose occurs again at 1850 feet, Cumloughra; *Veronica officinalis* at 1063 feet above Curraghmore Lake.

2200 feet.

[V]allii (Planch.)—Also at 2000 feet on Caher above Cummeena-[ca]ppul, 1350 feet in the Hag's Glen, and 1480 on Beenbane; quite [un]usual heights for the dwarf furze.

[Spiræa] Ulmaria (Linn.) *[Planta]go lanceolata* (Linn.) *[Juncus] articulatus* (Linn.)	See under *Primula vulgaris. Plantago lanceolata* occurs at 1800 feet above L. Curraghmore. *Spiræa Ulmaria* at 1350 feet above Curraghmore Lake.

HEAD OF CUMLOUGHRA.

2150 feet.

[pra]tensis (Linn.)—Scarce.

NORTH OF LOUGH GOOGH.

2100 feet.

[Pru]nella vulgaris (Linn.)—Scarce; at 1400 feet on Beenbane.
[c]æspitosa (Linn.)—See under *A. alpina* at 3100 feet above. At [1]80 feet on the south side of Cummeenmore Mountain.
[Lastre]a æmula (Brack.)—A remarkable altitude for this fern; occurs [als]o at 1340 feet above Lake Cummeenmore.

CLIFF AT S. W. OF CUMLOUGHRA.

2100 feet.

[Prim]ula vulgaris (Linn.)—Again at 1750 feet in the Hag's Glen. [It] is very unsafe to attempt to distinguish this plant from *P. [gra]ndiflora* when not in flower.

SOUTH SIDE OF CUMMEENMORE MOUNTAIN.

2080 feet.

[...]um minus (Linn.)—At 1500 feet on Mt. Brassel, above Callee [La]ke, and in several places from 1400 feet to 980 feet on Bull's [Mo]untain above the Gap of Dunloe.
[...]um Androsæmum (Linn.)—An unusual altitude for this plant to [be] found at; in one place only. See remarks under *Primula vul-[gar]is* at 2200 feet.

CAHER, ABOVE CUMMEENACAPPUL.

1950 feet.

[...]tralix (Linn.)—Finds its upper limit at 1750 feet in Cum-[lou]ghra; at 1550 feet on Cummeenapeasta, in the Hag's Glen, [and] at 1650 feet above Lake Curraghmore.
[g]lauca (Scop.)—Again at 1650 and 1550 feet, Cumloughra, &c.

HEAD OF CUMLOUGHRA.

1950 feet.

na (Linn.)—Again at 1780 feet by Lough Cummeenmore; 0, Cumloughra.

OVE LAKE CURRAGHMORE (TO THE NORTH-EAST.)

1800 feet.

machia nemorum (Linn.)—Again at 1780 feet by Lough Cummeenmore.

CARRAN TUOHIL VE CUMLOUGHRA).

et.

Aira præcox (Linn.)

LAKE ENMORE.

et.

Veronica serpyllifolia (Linn.)—At 50 feet in Cumloughra.
Myriophyllum alterniflorum (D. C.) At 1250 feet in Lough Callee, Mount Brassel; 1000 feet, Lake Curraghmore.

ABOVE LAKE CURRAGHMORE (TO THE NORTH-EAST).

1700 feet.

Pteris aquilina (Linn.)—At 1650 feet, Cumloughra; 1550 feet, Cummeenapeasta and Skregmore.

CUMLOUGHRA (AT S.-W. END).

1650 feet.

Saxifraga Geum (Linn.)—At 1150 feet on the Bull's Mountain, Gap of Dunloe; at 1090 feet, Breenbane. *S. hirsuta* occurs also near the lakes in Cumloughra, and in Glencaragh at about 700 feet. See introductory remarks.
Poa trivialis (Linn.)

HAG'S TOOTH.

1650 feet.

Agrostis alba (Linn.)

LAKE GOOGH.

1600 feet.

Potamogeton pusillus (Linn.)

CUMLOUGHRA LAKE LEVEL.

1550 feet.

anunculus Flammula (Linn.) *gina procumbens* (Linn.) *abiosa succisa* (Linn.) *alium palustre* (Linn.) *arthecium ossifragum* (Huds.) *ncus acutiflorus* (Ehrb.) *lyceria fluitans* (Brown.)	These, with most of the other lowland plants already mentioned, occur more freely now. The alpine flora has almost entirely disappeared.

HAG'S GLEN (ON CUMMEENAPEASTA).

1550 feet.

runella vulgaris (Linn.)—And at 1200 feet, head of Glencaragh.

BULL'S MOUNTAIN (ABOVE THE GAP OF DUNLOE).

1500 feet.

splenium Adiantum-nigrum (Linn.)

FINGLAS RIVER VALLEY.

1470 feet.

lex europæus (Linn.)
onicera Periclymenum (Linn.)

BEENBANE.

1450 feet.

Menyanthes trifoliata (Linn.)

LAKE EIGHTER (AT ENTRANCE TO CUMLOUGHRA.)

1425 feet.

ychnis Flos-cuculi (Linn.)
pilobium palustre (Linn.)
ttorella lacustris (Linn.)—At 1000 feet, Lake Curraghmore.
parganium minimum (Fries.)—And at 1250 feet, Lake Callee, Mount Brassel.
riophorum polystachyum (Linn.)—Upper limit at same height on Beenbane.
quisetum limosum (Linn.)

STREAM OUT OF LAKE EIGHTER.

1400 feet.

edum anglicum (Linn.)

Mountain above Lake Auger in the Gap of Dunloe

1400 feet.

itima (With.)—Not met with elsewhere on the Reeks.

Above Lake Cummeenmore.

1380 feet.

x Helix (Linn.)
phyllum silvestre (Linn.)
perennis (Linn.)
Betula alba (Linn.)
Salix caprœa (Linn.)

Above Lak Curraghmore.

1350 feet.

Trifolium repens (Linn.)
Salix aurita (Linn.)

Mount Brassel (South Side).

1) feet.

Ajuga reptans (Linn.)—And at 820 feet in Glencaragh.

Hag's Glen.

1350 feet.

Ilex aquifolium (Linn.)—The finest hollies I have ever seen grow grove farther down the glen by the Gaddagh River.

Cummeenacappul.

1350 feet.

Lathyrus macrorrhizus (Winn.)—Scarce: at 550 feet, near Acoose.

By the River Finglas.

1340 feet.

Euphorbia hyberna (Linn.)—At 1200 and 950 feet in Cummeen pul; common lower down.

Cummeenacappul.

1300 feet.

Salix cinerea (Linn.)—Very scarce and stunted.

LOUGH CALLEE, MOUNT BRASSEL.

1250 feet.

ubularia aquatica (Linn.)—And in Lake Acoose, 507 feet at the northern side.
obelia Dortmanna (Linn.) — And in most lower lakes, Acoose, Googh, &c.
otamogeton natans (Linn.)—And at 1100 feet, Lough Calle, Hag's Glen.
arex paniculata (Linn.)—At 975 feet, Beenbane; and 740 feet, Lake Curralee.

WATERSHED, BETWEEN RIVE[illegible] [illegible]IMEENDUFF.

120[illegible]

ntaurea nigra (Linn.)
ucrium scorodonia (Linn.)
hœnus nigricans (Linn.)—At 11[illegible]
iodia decumbens (Beauv.)—At al[illegible] [illegible] in Cummeenacappul.
actylis glomerata (Linn.)

LOUGH GOURA[illegible]

112[illegible]

latine hexandra (D.C.)—On the [illegible] [illegible]f the lake.
allitriche hamulata (Kutz.)—*C. verna* [illegible] [illegible]et, Lake Curraghmore.

BULL'S MOUNTAIN.

1100 feet.

ubus carpinifolius (W. & N.)

ABOVE LAKE CURRAGHMORE.

1100 feet.

icia sepium (Linn.)

SKREGMORE.

1100 feet.

yrica gale (Linn.)

1050 feet.

rosera rotundifolia (Linn.)—1010 feet on Beenbane; 1000 feet, east from Lough Acoose.
hynchospora alba (Vahl.)

LAKE CURRAGHMORE LEVEL.

1000 to 1010 feet.

Myosotis repens (Don.)
Senecio sylvaticus (Linn.)
Polygonum Hydropiper (Linn.)
Juncus supinus (Mœnch.)
J. bufonius (Linn.)
Holcus lanatus (Linn.)
Aira caryophyllea (Linn.)
Hymenophyllum tunbridgense (Sm.) — Forming dense and beauti carpets amongst large boulders by the north-eastern mar of the lake; 800 feet in Cummeenacappul.

WEST SIDE OF CUMMEENACAPPUL TO BEENBANE.

975 feet.

Anagallis tenella (Linn.)
Hypericum elodes (Linn.)

BY STREAM FROM LOUGH GOOGH.

970 feet.

Pinguicula lusitanica (Linn.)—At 950 feet, east of Lake Acoose. V scarce on the Reeks.

ABOVE LAKE ACOOSE.

950 feet.

Carex præcox (Jacq.)

CUMMEENACAPPUL.

950 feet.

Sonchus oleraceus (Linn.)

BULL'S MOUNTAIN.

940 feet.

Cotyledon Umbilicus (Linn.)

BETWEEN LAKE ACOOSE AND CUMLOUGHRA.

850 feet.

Drosera anglica (Huds.)

HAG'S GLEN.

850 feet.

Cratægus Oxyacantha (Linn.)—50 feet below this, cultivation f appears.

BY THE STREAM FROM LOUGH GOOGH.

850 feet.

cirpus Savii (S. & M.)—Not seen elsewhere.

BY SOURCE OF RIVER CARAGH, EAST OF MAGHANLAVAUN (BRIDA.)

850 feet.

rylus Avellana (Linn.)
achypodium sylvaticum (R. & S.)

82[illegible]

munda regalis (Linn.)

CUMMEENACAP[illegible]

800

tus corniculatus (Linn.)
nicula europæa (Linn.)

LAKE CURRA[illegible]

ymphæa alba (Linn.)
uphar lutea (Linn.)
marum palustre (Linn.)
ydrocotyle vulgaris (Linn.)
utellaria minor (Linn.)
tricularia vulgaris (Linn.)
alaxis paludosa (Sw.)—By the spongy margin of the lake in small quantity. This rare little orchid has been gathered in Kerry before.
arganium natans (Linn.)
irpus fluitans (Linn.)
rex vulgaris (Fries.)
limosa (Linn.)—Forming a fringe around the edge of the lake. This rare and graceful sedge has been gathered in one place in Kerry previously.
ampullacea (Good.)

CUMMEENACAPPUL.

720 feet (cultivation appears in patches.)

nunculus hederaceus (Linn.)
rduus lanceolatus (Linn.)
lleopsis Tetrahit (Linn.)
mex obtusifolius (Linn.)
riplex patula (Linn.)

NORTHERN BASE OF SKREGMORE AND SKREGBEG.

700 feet.

Carum verticillatum (Koch.) *Bartsia viscosa* (Linn.)	These two characteristic Kerry plants occur frequently from about the present height downwards all round the northern slope of the Reeks, by the western extremity, and into the valley of the river Caragh on their south. Their range is very similar and decided.

CUMMEENACAPPUL (WEST SIDE).

650 feet.

Hieracium Pilosella (Linn.)
Carex ovalis (Good.)

550 feet.

Viola tricolor (Linn.)
Pedicularis palustris (Linn.)
Veronica scutellata (Linn.)
Mentha aquatica (Linn.)
Sparganium ramosum (Huds.)

ABOVE LAKE ACOOSE.

550 feet.

Quercus Robur (Linn.)
Potamogeton polygonifolius (Pourr.)

BY THE STREAM FROM LOUGH GOOGH INTO BLACK VALLEY.

520 feet.

Arbutus Unedo (Linn.)—One old tree. I met with the arbutus nowhere else on the Reeks.

CUMMEENACAPPUL, WEST SIDE; BEENBANE.

500–510 feet.

Stellaria graminea (Linn.)
Rosa canina (Linn.)
Fraxinus excelsior (Linn.)

LAKE ACOOSE LEVEL.

500–510 feet.

humifusum (Linn.)
Robertianum (Linn.)
articum (Linn.)
upulina (Linn.)
pratense (Linn.)
Sm.)
esca (Linn.)
olor (W. and N.)
alicaria (Linn.)
tula (Linn.)
rota (Linn.)
ulgaris (Linn.)
s radicata (Linn.)
ns (Linn.)
bifolia (R. Br.)—Near Lougl lows.
tha (Bab.)—With the last.
folia (Linn.)
palustris (R. Br.)
ragmites (Linn.)

SOUTH SIDE OF MOU

500 feet

es radicans (Sw.)—A shepherd lad sho where he had gathered, and exterminated, the Killarney Fern here. I not find it anywhere on the Reeks, but it probably still at their base.

DRISHANA, WEST OF GAP OF DUNLOE.

(?) 400 feet.

sima (Linn.)—On stony ground near the base of the moun-y the river. This has not been recorded from Kerry before.

—ON THE EQUATION OF A TANGENT CONE TO A QUADRIC, REFE[RRED TO] THE AXES. By JOHN C. MALET, Professor of Mathem[atics], [Qu]een's College, Cork.

[Read, April 10, 1882.]

[F]ollowing purely analytical method of forming this equatio[n] ... new:—

[T]he quadric

$$ax^2 + by^2 + cz^2 + 2hxy + 2gxz + 2fyz + 2lx + 2my + 2nz + d = 0$$

be referred to its axes, the equation is

$$\frac{x^2}{\alpha} + \frac{y^2}{\beta} + \frac{z^2}{\gamma} + \frac{\Delta}{\delta} = 0,$$

where

$$\Delta = \begin{vmatrix} a & h & g & l \\ h & b & f & m \\ g & f & c & n \\ l & m & n & d \end{vmatrix}$$

$$\delta = \begin{vmatrix} a & h & g \\ h & b & f \\ g & f & c \end{vmatrix}$$

and α, β, γ are the roots of the cubic equation in λ formed by eq[uat]ing to 0 the discriminant of

$$ax^2 + by^2 + cz^2 + 2hxy + 2gxz + 2fyz - \frac{x^2 + y^2 + z^2}{\lambda} = 0.$$

If the quadric be a cone, Δ vanishes; and in this case being only [con]cerned with the ratios of α, β, γ, we may write $\frac{k}{\lambda}$ for $\frac{1}{\lambda}$, where k [is a] constant selected at will.

Consider now the equation of the tangent cone to the quadric

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} - 1 = 0,$$

viz.— $$SS' - P^2 = 0,$$

where $$S' = \frac{x'^2}{a^2} + \frac{y'^2}{b^2} + \frac{z'^2}{c^2} - 1,$$

and $$P = \frac{xx'}{a^2} + \frac{yy'}{b^2} + \frac{zz'}{c^2} - 1.$$

o refer this cone to the axes, equate to 0 the discriminant of

$$US' - \Pi^2 - \frac{S'(x^2 + y^2 + z^2)}{\lambda} = 0 \quad . \quad . \quad . \quad (A),$$

here
$$U \equiv \frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2},$$
$$\Pi \equiv \frac{xx'}{a^2} + \frac{yy'}{b^2} + \frac{zz'}{c^2}.$$

Differentiating (A) with respect to x, y, and z, we get the three equa-
ions

$$S'x\left(\frac{1}{a^2} - \ldots\right.$$
$$S'y\left(\frac{1}{b^2} - \ldots\right.$$
$$S'z\left(\frac{1}{c^2} - \ldots\right.$$

o eliminate x, y, z from these eq … espectively by,

$$\frac{\lambda x'}{a^2 - \lambda}, \quad \frac{\lambda y'}{b^2 - \ldots}$$

ld and divide by Π, when we fi…

$$S' + \lambda\left(\frac{x'^2}{a^2(a^2 - \lambda)} + \ldots \lambda)\right) = 0,$$

r
$$\frac{x'^2}{a^2 - \lambda} + \frac{y'^2}{b^2 - \lambda} + \frac{z'^2}{c^2 - \lambda} - 1 = 0.$$

ut the roots of this equation are $a^2 - a_1^2$, $a^2 - a_2^2$, $a^2 - a_3^2$, where a_1, a_2, a_3 are the semiaxes major of the confocals through x', y', z'; ence the equation of the tangent cone through this point is referred the axes,

$$\frac{x^2}{a^2 - a_1^2} + \frac{y^2}{a^2 - a_2^2} + \frac{z^2}{a^2 - a_3^2} = 0.$$

n a similar manner the equation of the tangent cone through x', y', z' the paraboloid

$$\frac{x^2}{L} + \frac{y^2}{M} - 2z = 0,$$

hen referred to the axes, is

$$\frac{x^2}{L - L_1} + \frac{y^2}{L - L_2} + \frac{z^2}{L - L_3} = 0,$$

here L_1, L_2, L_3 are the values of L for the confocal paraboloids rough the point x', y', z'.

LXXXI.—Report on the Clearing of Peaty Waters. Part II. By Gerrard A. Kinahan.

[Read, April 24, 1882].

Introductory Remarks.

In the previous Report[1] laid before the Academy it was shown, after a colorometric examination and comparison of certain streams, "that peaty colouring matter does not seem to be removed by direct oxidation." Since then I have been enabled, through the courtesy of Professor Hartley, F.R.S.E., &c., to make in his laboratory, at the Royal College of Science, analyses of samples of peaty waters in which there were facilities for oxidation, viz., aëration when falling from a great height.

In this Report it is proposed to lay before the Academy—First, the results of these analyses, and, in continuation, the analyses of some waters that receive a large amount of mineral drainage, with a short sketch of the nature of this drainage, and its effect on the peaty waters.

In the analyses the method adopted for estimating the organic carbon and nitrogen was a modification of Dittmar and Robinson's process.

The nitrogen, as nitrates and nitrites, was estimated in the following manner:—

100 cc. of the water was boiled for a short time; then, when cold, a small piece of clean platinum foil and some magnesium ribbon were put in, with a fragment of recently fused sodic chloride; after standing about 12 hours the ammonia was distilled off, and estimated by the Nessler test, and from this the nitrogen calculated.

This process is especially applicable to the estimation of very small quantities of nitrates and nitrites.

Waters becoming much Aërated.

The first waters to be described were taken from the Dargle river, at Powerscourt waterfall, in the autumn of last year (October, 1881). The day was bright, fine, and warm; but during the two previous days misty rain had fallen on the hills, so that there was a slight flood in the river, but it was not at all turbid, although it was stated by Lord Powerscourt's game-keeper, who accompanied me, to be unusually peaty.

The first sample was taken a short distance above the fall, at a point where the river flowed rapidly through a deep channel, four feet wide, in the solid rock (mica schist). From this to the foot of the fall, where the second sample was taken, the river flowed altogether over solid rock, excepting a few loose boulders and some coarse gravel lying in the channel above the top of the fall. No visible drainage of any kind enters the river between these two points, which are separated, horizontally 800 feet, and vertically 360 feet.

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[1] *Vide ante*, p. 447.

The Dargle river, above the Waterfall, drains a long mountainous en, with to the south a couple of small branches or cooms. The ountains of the drainage area are principally composed of granite, e mica schist only coming in a short distance above the fall. In a w places in the glen there are accumulations of moraine matter, while ere is a covering of peat over nearly the whole area.

There was no visible difference between the waters taken above d below the fall, either in the field or when examined and compared the laboratory in a tube 18″ long; both showed a clear, dark-brown at, with little suspended matter, while only a very slight brown diment collected at the bottom when allowed to stand.[2]

The analyses of these waters (Nos. I., II. Table A, p. 603), show that e samples are practically identical. The two important constituents— ganic carbon and nitrogen—being almost the same in each, the ight difference (probably due to experimental errors), being only two arts in the carbon and five in the nitrogen per 100,000,000 of the water. itrogen, as nitrates or nitrites, was not detected in either sample, though if any oxidation of the organic nitrogen took place during he fall, some should occur in the lower sample.

The waters next to be considered are from the Carawaystick brook, hich drains the eastern peaty slopes of Lugnaquilla. Here duplicate pecimens were collected in summer and winter. Although the gene- al features of this stream have already been described in the previous eport, we may mention that, after it leaves Kelly's Lough, and has owed for about one and a-half miles, it falls precipitately down the estern side of Glenmalure into the Avonbeg, by a succession of small, ften nearly perpendicular, falls, the aggregate vertical height of hich, between the points, being over 700 feet (as calculated by ane- oid), while horizontally they are 1600 feet apart. The channel of he fall is solid rock (granite and mica slate), with, in the clefts, &c., a ittle loose gravel; no side drainage appears to enter along the fall.

When the winter samples were collected, in January, 1882, there as a light mist on the hills, otherwise the day was fine and dry, but ot cold: although there had been considerable rain some days pre- iously the stream was not flooded, but rather below its average; the aters were very clear and only slightly coloured with peat, and in he 18″ tube they showed a light olive brown tint.

From the analyses as given in the Table (Nos. III. & IV.), we find hat the organic carbon and nitrogen are practically the same in both amples.

In the same Table, Nos. V. and VI. give the analyses of the sum- mer samples taken from the same points; they show the differences in he waters at these two seasons of the year; and it will be remarked hat the main differences are in the organic constituents, especially the rganic carbon.[3]

[2] In peaty waters usually, on standing, a brown sediment collects at the bottom.
[3] These examples are average samples of peaty water in summer and winter.

In the next two analyses on the Table (Nos. VIII. & IX.) there is a very marked difference in the organic constituents. The waters were taken from the Ovoca river at two points—Tigroney weir and "The Black Dog"—about three miles apart, and with a fall of only 50 feet. On comparing the two, it is evident that the conditions in the intervening portion of the river are favourable for the removal of the peaty impurities. The most marked peculiarity in this part of the river is the mineral drainage (largely impregnated with sulphates of iron and alumina) that enters it, consisting of a number of small streams, which, taken together, form only a small fraction of the total volume of the main river; nevertheless, the organic carbon is reduced from 0·230 at Tigroney to 0·095 at "The Black Dog," or to less than half that previously present. The organic nitrogen suffers a reduction also, but not to the same extent: while, on the other hand, the total solids have largely increased; viz., from 4·88 at Tigroney to 9·26 at the "Black Dog," or nearly double.

In selecting streams from which to obtain aërated samples it was necessary that, between the points at which the samples were taken, there should be no alteration of circumstances likely to affect the waters, except simple unaided aëration: both the rivers from which samples were obtained (Dargle river and Carawaystick brook) are of very soft water, and, unfortunately, samples of hard water, affected only by aëration over a steep fall could not be secured; the Doonass fall, on the Shannon,[4] was visited and samples collected on both sides of the river, above and below the falls, but the results were most unsatisfactory, as there was a greater difference between the two samples from opposite banks, above the falls, than between either of these samples and those taken from below the falls. The analyses are given at the end of the Table (Nos. X.–XIII.)

In collecting the samples and in making the analyses, exceptional

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It is remarkable that in winter the rivers show very little peaty colouring. All through last winter this was the case (although there was an absence of frost and snow); but the rains towards the end of March brought down much peaty colouring: this probably may be due to the return of vegetation, which is early this spring (1882).

[4] On writing about the floods in this river to my father, who lived for some years in this neighbourhood, part of the time at Castleconnell, I received the following note:—

"In the Shannon, between Killaloe and Castleconnell, the flood waters from the counties of Tipperary and Limerick, on the S.E. and S., are 'black floods' (peaty water), especially those that flow into it between O'Brien's-bridge and Castleconnell; while the flood waters from the Clare side, to the N. and N.W., except the stream from O'Brien's-bridge bog, are 'red flood, highly charged with the red muds from the *debris* of the red basal Carboniferous shales. These different classes of flood may differently affect the water at the Falls of Doonass. If rain falls only in the counties of Tipperary and Limerick, there will be a 'black flood' over the falls; while, if the rain falls only in the county Clare it will be a 'red flood'; but if the rain is falling at both sides of the Shannon, the results will be very different. If, during such a rain-fall, you stand at the World's End weir, Castleconnell, the flood on the Limerick side will be black, and that on the Clare

precautions were taken that nothing likely to mar the results should occur. In estimating the organic constituents duplicate analyses were made in most cases, and in the weighings for the organic carbon the allowable error was taken as under three-tenths of a milligram.[5]

These results seem clearly to show that simple aëration is incapable of effecting the removal of the peaty matter. The Powerscourt samples were taken in summer, on a warm sunny day, when the waters were deeply tinted with peaty colouring matter, yet the difference between the two samples is practically nothing, although the fall is 360 feet, and the aëration exceptional. In the Glenmalure water we have samples taken on a fine day in winter, when the quantity of peaty matter was not excessive; and although in this case the fall is over 700 feet, the two samples are practically identical.

In the samples taken from the Ovoca river the results obtained are of quite an opposite character to those of the two preceding samples: here there is but a fall of 50 feet in a flow of three miles, and aëration can have but a slight effect. That the active agent is the mineral drainage, which enters the river in the intermediate portions, seems evident from the results of the experiments given in the previous Report.

The nature of these mineral waters we now propose giving a brief sketch of; but before doing so it seems desirable to give some account of the head waters of the river, more especially as all at some time have received more or less mine drainage.

The Principal Mineral Impurities of the Ovoca.

The present Ovoca river[6] is formed by the junction of the Avonmore and Avonbeg, at the *Upper* "Meeting of the Waters," and flows into the sea at Arklow, having been joined by the Daragh water, or Aughrim river, at Woodenbridge, or *Lower* "Meeting of the Waters."

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side red; the two differently-coloured waters going separately over the weir to be slightly mixed below, but the great mixing does not take place until they reach the Falls of Doonass, below which the red ferriferous waters are found to have cleared out the peaty colouring matter. The waters flowing over the falls are more often coloured with peat than otherwise. While living at Castleconnell some of the largest floods I saw on the falls were black ones. When the rain falls only to the southward of the Shannon, the 'black flood,' going over the fall, is met by a 'red flood,' coming out of the Annacotty, or Mulkear river, which neutralises and destroys the peaty colour in the water before it reaches Limerick. On account of the difference in the land on each side of the Shannon above Castleconnell the waters on each side of the river above the falls must give very different analyses."

[5] This would be as carbonic acid, so that the carbon would be $\frac{3}{11}$ of this, or about one-tenth of a milligram, which was usually on a litre of water; but in the analyses of Nos. V., VI., VII., and X.–XIII. where only 500 cc. water was used, the error was larger than this. The figures given in the Table are the means; except in those cases on which inferences are based, when the two results are stated, viz.: Nos. III. and IV., VIII. and IX.

[6] Formerly the river, as far down as Woodenbridge, was included in the Avonmore, while the river below this, in some accounts of the district written in the last century, is called the "Ovo."

The head waters of the Avonmore rise in the mountains about Glendalough (of St. Kevin) and Luggala. The Annamoe flows from Luggala; it seems to be quite free from mineral poisoning, although mining trials have been made at Lough Dan. The tributary streams which contain most mineral drainage are those from Glendalough lakes and from the vale of Glendassan, into both of which the drainage from the Luganure and Camaderry mines flow. How long these rivers have been poisoned it is hard to say; mining operations were carried on here during the last century, yet in 1832 Glendalough and Lough Dan were noted for containing the char[7] (*Salmo alpinus*), which is now confined to Lough Dan.

A sample of water taken in Glendassan, a little below where the mine drainage enters, contained in parts per 100,000, solids 7·5; of which 0·08 were lead, with a little iron, and a trace of sulphuric acid.

A sample taken at Clara bridge, after a flow of about six miles from where the last sample was taken, with a fall of about 600 feet, contained 0·04 parts lead; and one taken three miles lower down at Rathdrum mill contained 0·035 parts lead: while a fourth, taken at the Meeting of the Waters, about 13 miles from the mines, with a fall of about 900 feet, contained 0·02 parts lead. These four samples were taken on the same day, after there had been dry weather for about six weeks. The waters were very clear, with only a faint peaty tinge.

On another occasion, when the river was in slight flood, samples were taken at Clara bridge, and at the Meetings, which gave, respectively, 0·02 parts lead, and only a faint trace.

Besides this mineral drainage from Glendalough, a small quantity of mine waters enters the river between Rathdrum and the Meetings; it is, however, very insignificant, the largest stream being that at Shroughmore, flowing from Connary. The Avonbeg, which joins the Avonmore at the Meetings, has its head waters in the hills about Glenmalure, one of its principal tributaries being the already-mentioned Carawaystick brook. Some years ago lead mines were worked in Glenmalure, and the drainage from them poisoned the river so that no fish could live in it; but now, as the deleterious mineral matter has disappeared, it has become stocked with trout from the mountain streams. This river, flowing into the Ovoca river at the Meetings, supplies large quantities of peaty water.

After the junction of the two rivers, Avonmore and Avonbeg, at the Meetings, the waters flow for about a quarter of a mile to Tigroney weir, where they become thoroughly mingled. A little above this some mineral drainage enters on the left bank; but it is about a quarter of a mile lower down, in the vicinity of the Bell rock, that the principal mine waters enter, after having passed through the copper launders. On the left, or east bank, the river receives the main drain-

[7] Char are said to have again appeared in Glendalough since the mines at the west end ceased working. A salmon is said to have been seen in the Daragh water, on June 3, 1882.

from Tigroney and Cronebane mines; and on the right bank that Ballygahan and Ballymurtagh. Both these waters are very similar, are treated very similarly for the extraction of the copper before ering the river.[8] They are the underground drainage of the mines, in sulphates of copper, iron, and alumina, with smaller quantities other substances. The copper is extracted by running the water r metallic iron, the copper being deposited in the metallic state, an equivalent amount of iron passes into solution, while, at the e time, a quantity of gas is evolved, which where the launders are lerground is found to be highly inflammable; it seems to be hydro-, due to the decomposition of the water, and is probably mixed with ro-carbons; the iron exists mostly in the ferrous state, and it is till the greater part of the copper has been deposited that it becomes osited as ochre.[9]

A sample of the Ballygahan water, taken from the launders, was ured a deep brown, and contained some ochre in suspension; it strongly acid, with a metallic taste. Its constituents are given 'able B, No. VI. (p. 604). These probably all occur as sulphates; and, ulating them as such, we find as follows in grains per gallon:—

Sulphate of copper, ...	29·5.
Sulphate of iron, ...	710·7.
Sulphate of alumina, ...	712·8.
Sulphate of manganese, . . .	10·7.
Sulphate of zinc, ...	6·0.

The most interesting constituent of this water is a small trace of alt. Nickel, however, was not detected.

On the opposite bank, the drainage from the Tigroney and Crone-e mines, as it enters the river, is almost identical, in general com-ition, with that of Ballygahan; it, however, contains each consti-nt in less quantity.

The river, below where this drainage enters, has in general, but re markedly during warm dry weather, a somewhat turbid appear-e: this is probably due to the separation and deposition of the salts ron and alumina.

Some distance below the Ballygahan waters another mineral stream ers, on the same side, which comes down from the mines of Bally-rtagh, along the Red road. This water contains very little mineral s, as compared with those just mentioned.

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[8] These waters appear to have attracted some attention during the last century, are described in Rutty's *Mineral Waters of Ireland* (1757), pp. 241–245; osophical Transactions, for 1751 to 1753, by Kenroy, Henry and Bond.

[9] This ochre consists of hydrated ferric oxide and a basic sulphate (Fe_2SO_6), ch separates, in the presence of cast iron, thus:

$$Fe_2O_3\,(SO_3)_3 + Fe_2 + 2H_2O = Fe_2O_3SO_3 + 2FeSO_4 + 2H_2.$$

reaction also accounts for the hydrogen; but some of this is also produced by couple formed by the iron and copper.

A short distance lower down, on the same bank, a
enters at Tinnahinch, coming from a spa, and also
drainage from the waste heaps along the mine tramway.
were clear, but an ochreous precipitate settled out on e
air; they are acid, but rather weak mineral waters.

On the opposite or left bank, some distance lower do
north of the village of Newbridge, a small stream—
brook—enters: formerly this was the principal source c
purity to the Ovoca river, as it received all the drainag
Cronebane and most of that of Connary; but this now
Tigroney, and the mineral matter in the stream is deri
waste heaps, or attals, on the surface: considerable quan
have been deposited along its course.

Below this a small stream enters, on the right ba
macadam; it drains the lands about the Ballymoneen
some time ago were worked for sulphur and iron ores; i
ever, free from injurious mineral impurities, and is inha
fish.

This short sketch of the mineral drainage from th
shows that by it a large amount of salts in solution
Ovoca river: this is evident both from the quantities of
of the samples, and from the fact that the total solids in
ples of the river water increased from 4·88 parts, at Tig
9·26 parts per 100,000, or very nearly double, at the B
true estimate, however, of the total quantity entering ca
such would require a series of careful measurements a
each stream, at different seasons of the year. Though
waters have the general effect of freeing the Ovoca rive
impurities, the river, on the other hand, is literally pois
and no fish are to be found in it from Tigroney weir
Arklow.

Conclusions.

In this Report I hope it has been clearly shown :—

That the colorometric method of examination of
adopted in the first part, is a fair relative, although no
method of analysis.

That the action of the air which the water of a river i
is incapable of oxidizing the peaty matter, either in wint
even when the natural conditions are most favourable
waters are dashed into foam down a steep and great hei
therefore, the same will be true, *a fortiori*, in a slow

									$CaCO_3$.		
Dargle R.		POWERSCOURT FALL.									*Collected Oct.* 1, 1881.
	I.	Above falls, . . .	0·946	0·072	0·001	0·000	0·073	0·84	1·27	4·20	Clear, but deeply coloured with peaty matter.
	II.	Below falls, . . .	0·944	0·077	0·001	0·000	0·078	0·88	1·27	4·40	
Carrawaystick River.		GLENMALURE FALLS. *Winter.*									*Collected Jan.*, 1882.
	III.	Above falls, . . .	0·284 / 0·286	0·022 / 0·025	0·000	0·004	0·026 / 0·029	1·50	0·95	3·26	Slightly coloured with peaty matter, clear.
	IV.	Below falls, . . .	0·284 / 0·289	0·021 / 0·025	0·000	0·004	0·025 / 0·029	1·60	0·95	3·34	
		Summer.									*Collected Aug.* 15, 1881.
	V.	Above falls, . . .	1·06	0·054	trace	0·000	0·054	1·30	0·95	—	Deeply coloured with peaty matter.
	VI.	Below falls . . .	1·17	0·053	trace	0·000	0·053	1·40	0·95	—	
	VII.	Kelly's Lough, . .	0·68	0·054	trace	0·000	0·054	1·20	0·62	—	Rather peaty.
Ovoca.											*Collected Jan.* 16, 1882.
	VIII.	Tigroney Weir, . .	0·231 / 0·229	0·026 / 0·028	trace	0·011	0·037 / 0·039	1·80	1·27	4·88	Slightly peaty.
	IX.	Black Dog, . . .	0·098 / 0·093	0·019 / 0·019	trace	0·008	0·027	2·30	2·60	9·26	Colourless, trace Fe.
Shannon.		DOONASS FALLS.									*Col. July* 16 & 18, 1881.
	X.	Right bank above, .	1·036	0·053	0·004	trace	0·057	1·75	14·44	—	Slightly tinted with peaty colouring matter, and suspended matter.
	XI.	Left bank above, . .	0·818	0·040	0·002	trace	0·042	1·70	14·44	—	
	XII.	Right bank below, .	1·063	0·049	0·002	trace	0·050	1·87	14·75	—	
	XIII.	Left bank below, . .	1·090	0·045	0·001	trace	0·046	1·87	14·44	—	

EXPLANATION OF THE TABLE.—Samples Nos. I. and II. in the Table show the effects of aëration on peaty water in Summer, while Nos. III. and IV. show the same in Winter. Nos. III., IV., V. and VI. are a series of comparative analyses of the same stream in Winter and Summer. No. VII. the analysis in Summer of the reservoir from which one of the tributaries of this stream springs, the drainage being mainly underground. Nos. VIII. and IX. are samples of water from a river receiving a large accession of mineral impurity, and with little aëration. Nos. X.-XIII. are analyses of samples from opposite banks of a large river above and below the falls.

Table B.—*Analyses showing chief Inorganic Impurities of the River Basin. Results stated in parts per 100,000.*

Avonmore.

No.	Where obtained.	Chief impurities determined.	Present, but not quantitatively estimated.	Traces detected.	Rema
I.	Glendassan,	Lead, . . 0·08 Total solids,. 7·5	— —	Fe, As H_2SO_4	Turbid, much sus matter, r
II.	Clara Bridge,	Lead, . . 0·04 Total solids,. 4·1 Inorganic solids, 3·1 Chlorine,. . 1·4	— — — —	As H_2SO_4 — —	Clear, bu slightly p
III.	Rathdrum Mill,	Lead, . . 0·035 Solids, . . 3·9 Chlorine, . 1·6	— — —	— — —	Slightly p
IV.	Meeting of the Waters,	Lead, . . 0·02	—	—	Clear, and peaty.

Small Tributaries of the Ovoca.

No.	Where obtained.	Chief impurities determined.	Present, but not quantitatively estimated.	Traces detected.	Rema
V.	Tigroney (launders),	Iron, . . 163·0 Alumina, . 197·5	Cu, Mn Mg, H_2SO_4	As, Pb Zn	Brown, w ochre in s sion, acid
VI.	Ballygahan (launders),	Iron, . . . 199·0 Alumina, . 214·0 Copper, . . 7·5 Manganese, 3·9 Zinc, . . . 2·4	Mg H_2SO_4 — — —	Pb As Co Ca —	Brown, w ochre in s sion, acid
VII.	"Red Road" Stream,	Ferric Oxide, Alumina, } 3·8 Copper, . . 0·05	Mg H_2SO_4	— —	Colourles ochre in s sion, sligh acid.
VIII.	Tinnahinch Stream,	Iron, . . . Alumina. . } 4·8 Copper, . . 0·02 Solids, . . 22·5	Mg H_2SO_4	Zn Ca	Colourles brown sed slightly a
IX.	Sulphur Brook,	Solids, . . 12·8	Mg	Fe_2O_3, Zn Al_2O_3 H_2SO_4	Colourles brown p tate, faint

LXXXII.—On the Effects of the Lunar and Solar Tides in Lengthening the Duration of the Sidereal Day. By the Rev. Samuel Haughton, M.D., Fellow of Trinity College, Dublin.

[Read, November 14, 1881.]

The idea of a lengthening of the sidereal day, by means of the tidal effects of the moon and sun, was started by the late astronomer Delaunay, as a means of explaining the difference of the coefficient determining the moon's mean motion,

$$10{\cdot}2\, n^2,$$

found by Halley from ancient eclipses, and confirmed by Laplace by calculation; and the coefficient, found by Adams's correction of Laplace's calculation,

$$6{\cdot}11\, n^2.$$

Delaunay found that a lengthening of the sidereal day by one second in 100,000 years, would reconcile Halley's coefficient with Adams's correction of Laplace's coefficient; and he also made an attempt to calculate the lengthening of the day producible by the tidal influence of the moon and sun. As, however, he made his calculation on the equilibrium theory of the tides, and also assumed an inadmissible range of ocean tide, it is desirable to repeat his calculations on more correct data, which I have attempted to do in the following Paper.*

I shall consider two effects of the tidal action of the moon and sun—

1. The effect of the *Residual Tidal Current*, which is of the second order, as compared to the second.

2. The effect of the *Distortion Couple*, caused by the displacement of the tidal spheroid by friction, and accompanied by acceleration of tidal phase.

Proposition I.

It is required to find the rate of lengthening of the sidereal day, caused by the residual current produced by the tidal action of the moon (supposed to be always in the equator) upon the ocean, collected into an equatorial canal, of constant width and depth.

The ocean occupies about three-fourths of the surface of the earth, and is about two miles deep, on the average. If this quantity of water

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* I believe that Mr. William Ferrel, of the U. S. A. Coast Survey, has made an attempt similar to my own; but as I have not seen it, I can only acknowledge here his possible priority.

be placed in an equatorial canal, extending ten degrees on north and south of the equator, such an equatorial canal about ten miles in depth.

The velocity of the water produced in such a canal, by rotation and action of the moon, is

$$u = V_0 + \frac{k}{2\omega}\cos 2m,$$

where V_0 = equatorial velocity of the earth's surface,

$$k = \frac{3}{2}\frac{M}{R^2}\frac{r}{R} = \frac{3}{2}\frac{M}{R^2}\frac{a}{R}\frac{r}{a} = \frac{1}{400{,}000}\frac{r}{a};$$

$$\omega = \frac{2\pi}{T};$$

m = moon's hour angle;

a = mean value of r.

If the alteration in the shape of the water caused by action be neglected, and r considered always equal to a, tion (A) summed all round the equator will give

$$u = V_0,$$

for the periodic term will disappear, and no effect will be the moon in retarding or accelerating the rotation of the however, we take account of the altered shape of the wate

$$\frac{r}{a} = (1 - \epsilon\cos^2 m),$$

where

$$\epsilon = \frac{c-a}{a};$$

c and a being the greater and lesser semiaxes of the tidal

The periodic term in (A) thus becomes

$$udm = \frac{k}{2\omega}\left\{\left(1 - \frac{\epsilon}{2}\right)\cos 2m\,dm - \frac{\epsilon}{4}(1 + \cos 4m)\,dm\right.$$

which, when summed all round the circumference, leaves a

$$Residual\ Current = -\frac{k}{2\omega}\times\frac{\pi\epsilon}{2}.$$

This small permanent residual tidal current acts in a direction opposed to the earth's rotation, and lengthens the sidereal day.

Let us proceed to calculate its magnitude.

We have

$$k = \frac{1}{400{,}000}, \quad \omega = \frac{2\pi}{T},$$

where $T = 89{,}280$, the number of seconds in a lunar day.

Hence

$$\frac{k}{2\omega} = \frac{89{,}280}{4\pi \times 400{,}000} = 0{\cdot}01775 \text{ ft. per second.}$$

$$\textit{Residual Current} = -\,0{\cdot}01776\,\frac{\pi\epsilon}{2}.$$

If we suppose a circle described, with radius a, at the surface of this circle $\epsilon = 0$, and if ϵ_0 be the ellipticity of the tidal ellipse at the surface of the water, all the layers of water lying between the ellipse and circle will leave a residual tidal current depending on the values of ϵ, which range from $\epsilon = 0$ to $\epsilon = \epsilon_0$. The whole water between the circle and ellipse will therefore have a residual tidal current corresponding to $\epsilon = \frac{\epsilon_0}{2}$. The whole mass of water, taken for both sides of the ellipse, will be represented by

$$\pi w\,(ca - a^2),$$

where w denotes the width of the equatorial canal, and c the longer semiaxis of the tidal ellipse. This mass may be written—

$$m = \pi w a^2 \epsilon_0.$$

The retarding couple of the residual tidal current will therefore be—

$$\delta G = -\,0{\cdot}01776 \times \frac{\pi\epsilon_0}{4} \times \pi w a^2 \epsilon_0 \times a,$$

where G represents the couple animating the whole earth; or,

$$\delta G = -\,\frac{0{\cdot}01776\,\pi^2 \epsilon_0^{\,2} a^3 w}{4} \qquad (D)$$

Now,

$$G = \omega I = \frac{\omega M a^2}{3{\cdot}06} = \frac{V_0 M a}{3{\cdot}06}, \qquad (E)$$

where I is the earth's moment of inertia with respect to the axis of rotation, and V_0 is the earth's velocity at the equator.

From (E), which may be written

$$GT = 2\pi I,$$

we have

$$G\delta T + T\delta G = 0.$$

Hence

$$\delta T = -\frac{T\delta G}{G}.$$

Substituting the values of δG and G, we find

$$\delta T = + \frac{0{\cdot}01776 \times 3{\cdot}06 \times \pi^2 \epsilon_0^2 a^3 w \times T}{4 V_0 M a};$$

but

$$V_0 = \frac{2\pi}{T} a,$$

$$M = \frac{4}{3}\pi a^3 \times 5{\cdot}5.$$

Hence

$$4 V_0 M a = \frac{32 \times 5{\cdot}5 \times \pi^2 a^5}{3T},$$

and

$$\delta T = + \frac{0{\cdot}01776 \times 3 \times 3{\cdot}06 \times T^2 \times \epsilon_0^2 w}{32 \times 5{\cdot}5\, a^2} \delta t,$$

or

$$\delta T = + \frac{T^2 w}{1080\, a^2} \epsilon_0^2 \delta t. \qquad (F)$$

If we express δt in terms of the number of years requisite to produce any given diminution δT, in the length of the day, we have

$$\delta t = 365{\cdot}25 \times Tn,$$

which converts (F) into

$$\delta T = + \frac{365{\cdot}25\, T^3 w}{1080\, a^2} \epsilon_0^2 n; \qquad (F\ bis)$$

$$T = 86{,}400 \text{ seconds} = \text{sidereal day};$$

$$w = 20 \times 60 \times 6000 = 7{,}200{,}000 \text{ feet};$$

$$a = 21{,}000{,}000.$$

bstituting these values, we finally obtain

$$\delta T = + 3{,}561{,}000\, \epsilon_0^2 n. \qquad (F\ ter.)$$

range of tide for an equatorial canal, with moon in equator, is

$$c - a = \frac{k\delta}{\omega^2 a},$$

ere δ is the depth of the canal.
ace, we have

$$\epsilon_0 = \frac{c-a}{a} = \frac{k\delta}{\omega^2 a^2}. \qquad (G)$$

bstituting the proper values, we find for the equatorial canal, 10 es in depth,

$$c - a = 1{\cdot}275 \text{ feet},$$

$$\epsilon_0 = \frac{1}{16{,}500{,}000}.$$

stituting this value in (*F ter.*) we find

$$\delta T = + \frac{n}{76{,}130{,}000}. \qquad (H)$$

t would therefore take upwards of 76 million years for the residual current produced by the moon, in the ocean collected into an equatorial l, to increase the length of the day by one second.

rollary.—As the tidal effect of the sun is one-half the tidal effect he moon, the residual current produced by both would take up-ds of 50 million years to lengthen the day by one second.

PROPOSITION II.

It is required to find the rate of lengthening of the sidereal d by the displacement of the tidal spheroid by friction; under conditions as those stated in the last Proposition.

When there is no friction, the minor axis of the tidal points to the moon, and the major axis is at right angles to t direction.

In the case of an equatorial canal, with the moon alw equator, if f denote the coefficient of friction, supposed prop the relative velocity of the moving water, the velocity of t represented by

$$u = V_0 + \frac{k}{2\omega}\left(\cos 2m - \frac{f}{2\omega}\sin 2m\right).$$

The periodic term vanishes, not when $m = 45°$, but when m where x is found from the equation

$$\tan 2x = -\frac{f}{2\omega}.$$

The tidal spheroid is, therefore, displaced through an an direction opposite to the earth's rotation, and the phases of all places are *accelerated*. If ϕ be the complement of x, the of the tidal spheroid will form an angle ϕ with the direct moon, and the two caps of water lying between the ellipse already described will give rise, by the action of the moon moon, to a retarding couple, which tends to lengthen the da

The magnitude of this couple is

$$km \times \sin 2\phi \times a,$$

where m is the mass of water lying between the ellipse and

$$\textit{Retarding couple} = \delta G = \pi w k a^2 \epsilon_0 \sin 2\phi.$$

This couple is of the first order with regard to ϵ_0, where tarding couple produced by the residual tidal current was of t order only.

Hence we have, as before,

$$\delta T = + \frac{3 \times 3{\cdot}06 \times T^2 w k \epsilon_0 \sin 2\phi}{8\pi \times 5{\cdot}5\, a^2}\,\delta t.$$

Substituting $k = \dfrac{1}{400,000}$, and reducing, we find

$$\delta T = + \frac{T^2 w \epsilon_0 \sin 2\phi \, \delta t}{6,023,000 \, a^2};$$

or,

$$\delta T = + \frac{365{\cdot}25 \, T^2 w \epsilon_0 n \sin 2\phi}{6,023,000 \, a^2};$$

or

$$\delta T = + 638{\cdot}57 \, \epsilon_0 n \sin 2\phi. \qquad (L)$$

Comparing this with the rate of retardation caused by the residual tidal current, we find the ratio of the rates of retardation to be, after the same number of years,

$$\frac{638{\cdot}57 \sin 2\phi}{3,561,000 \, \epsilon_0};$$

or

$$\frac{\sin 2\phi}{5577 \, \epsilon_0};$$

or, since

$$\epsilon_0 = \frac{1}{16,500,000},$$

ratio of rates of retardation = $2959 \sin 2\phi$.

With any sensible value of ϕ, this retardation will greatly exceed that caused by the residual tidal current.

Substituting for ϵ_0 its value, equation (L) becomes

$$\delta T = \frac{n \sin 2\phi}{25,839}. \qquad (L \; bis)$$

We have also, if x be the acceleration of tidal phase,

$$f = 2\omega \times \tan 2x;$$

$$f = \frac{4\pi}{T} \tan 2x;$$

$$f = \frac{\tan 2x}{6875{\cdot}5}.$$

From this we calculate the friction corresponding to any value of x:—

Acceleration of phase x.	$2x$.	$\frac{1}{f}$	Number of years required to lengthen the day by one second. n.
5°	10°	38,993	148,800
10	20	18,890	75,548
15	30	11,190	51,668
20	40	8,194	40,291
25	50	5,769	33,731
30	60	3,970	29,836
35	70	2,502	27,497
40	80	1,212	26,238
44½	89	120	25,843
45	90	0	25,839

Corollary (1).—If we take account of the sun, as well as of the moon, the number of years in the last column should be reduced by one-third; so that a friction whose coefficient is $\frac{1}{38,993}$, corresponding to a tidal acceleration of phase of 5° (or 20^m), would increase the length of the day by one second in 100,000 years. This is the amount of retardation necessary to reconcile Halley's coefficient of the moon's secular increase of mean motion, derived from ancient eclipses, with the correction in Laplace's coefficient made by Professor Adams.

Corollary (2).—With an amount of friction corresponding to an acceleration of phase of 5° (or 20^m), the water at the equator should rise 812 feet above the level before a surface current could flow towards the poles.

LXXXIII.—ON THE COMPARATIVE EFFECTS OF TWO METAMERIC BODIES ON THE GROWTH OF NICOTIANA LONGIFLORA. By J. EMERSON REYNOLDS, M.D., F.R.S., Professor of Chemistry, University of Dublin.

[Read, April 10, 1882.]

THE study of the comparative action of metameric compounds on the growth of plants seems to deserve more attention than it has yet received from chemists and vegetable physiologists, and the aim of the communication I now beg to lay before the Academy is to show that well-marked differences in physiological activity can be detected with the aid of plants, even in cases of metameric bodies of comparatively simple constitution.

The bodies selected for experiment were ammonium sulphocyanate and its metamer thiocarbamide, or sulphurea. Both compounds are rich in nitrogen, and therefore capable of supplying a highly important element of plant food; they are easily soluble in water, and, consequently, admit of absorption through the roots of plants; moreover, their chemical relations have been carefully studied, and their differences of structure are known, hence they seemed to be very suitable for the class of work in which I proposed to employ them.

The sulphocyanate is a true ammonium salt of sulphocyanic acid, and its composition is represented by the formula

$$NH'_4\,CNS'.$$

The metamer of this body, or thiocarbamide, I discovered in 1869, and obtained in the following way:—

The salt was melted, and the temperature of the liquid raised to 170° C., when rearrangement of the components of the molecule took place; the mass, when cooled, extracted by water and crystallized, afforded fine crystals of thiocarbamide. This body contains the same elements as the sulphocyanate, and in the same proportions, and its molecular weight is the same; but its relations and chemical structure are very different, as it is a feeble base, and destitute of saline characters, while its reactions are represented by the structural formula—

$$CS\,\frac{NH_2}{NH_2}.$$

During the summer of 1881, I made several sets of experiments with these bodies on selected groups of plants which are known to afford special nitrogenised or sulphuretted products, when grown under normal conditions. Some of the results obtained are sufficiently definite to justify their publication, while others require repe-

tition under new conditions. In the present communication I shall confine myself to the statement of experiments made with a variety of the tobacco plant (*Nicotiana longiflora*). The seeds were obtained from Messrs. Veitch & Sons, and afforded a good crop of young plants, which were removed from the seed-bed, and potted singly in very sandy mountain loam, of rather poor quality, the aim being to give the plants no more nourishment than was absolutely necessary to ensure moderate development. When the plants were shifted into four-inch pots, they were allowed to become thoroughly established, and the experiments commenced.

Several sets of three healthy plants were picked out, and the members of each set were as nearly as possible in the same stage of development, *i. e.* they were of the same height, had an equal number of leaves, and equally strong stems. Each set was subjected to the same treatment; but it will conduce to clearness if I trace that of a single set.

The treatment pursued was the following:—

No. 1. was watered with Vartry water only, when necessary.

No. 2 was watered twice each week with a solution of 0·5 gram of pure thiocarbamide in 250 c.c. of water: at other times it was treated as No. 1.

No. 3 was watered twice each week (unless otherwise stated) with a solution of 0·5 gram of pure ammonium sulphocyanate in 250 c.c. of water.

The plants were under glass, but so placed as to get equal light, and to prevent any undue tendency to drawing up or "spindling."

The first to show any effects was No. 3 (*i. e.* that treated with the sulphocyanate); at the third treatment with the solution the growth was checked, and the plant seemed not only to stop development, but even to shrink in a curious way; the leaves began to droop, and became rather sickly in colour. The fourth application only intensified the symptoms of plant-poisoning by the sulphocyanate, hence the treatment was stopped, and the soil well washed out by percolation of pure water: after this the plant recovered somewhat, and recommenced growth; but it received another dose, which again checked development. Washing the soil was repeated, and another rest allowed. This treatment was continued for nearly three months, up to the 1st of December, when it presented a very miserable appearance, and was in the condition stated in the Table. This plant was then removed from the soil, and dried.

There is no doubt that I could have killed this plant at any time by continued doses of the sulphocyanate, for corresponding plants of other sets so treated with the salt were destroyed in a few weeks.

No 2 plant (*i. e.* that treated with the solution of thiocarbamide) soon gave evidence that it felt the effect of its dose, but the result

was very different from that observed in No. 3; the stem did not elongate much, but the leaves rapidly developed in length, breadth, and substance, and assumed a healthy deep-green hue. It was noticed, however, that the development was less satisfactory where the solution of thiocarbamide was alone used for watering, than where there was a washing of the soil with pure water between two doses; in the former case the edges of the lower leaves becoming discoloured and thin. The reason for this is not far to seek; for the thiocarbamide is known to undergo partial reconversion into sulphocyanate in aqueous solution, and more especially in presence of such decomposable bodies as are found in the soil. The check in development of the plant doubtless followed this partial reversion.

With the slight modification in the treatment just referred to, the plant developed remarkably; until, on the 1st of December, it was in the state described below.

No. 1 Plant (*i. e.* that treated with plain water) grew rapidly, and soon outstripped the others in height, but its stem and leaves were poor and thin as compared with No. 2.

The following Table contains the measurements, &c., of the plants, on the 1st of December:—

	No. 1 (Water).	No. 2 (Thiocarbamide).	No. 3 (Sulphocyanate).
Total height in inches from surface of soil, ...	31	23	12
Number of leaves, ...	15	14	13
Maximum length of leaf in inches, ...	9½	15¼	8
Maximum breadth of leaf in inches, ...	4¼	6	2½
Number of seed pods in different stages of development,	9	15	None.
Number of seed pods well developed, ...	1	11	None.

Corresponding results were obtained with the other sets of tobacco plants.

The next step would obviously be the determination of the relative proportions of nicotine derivable from the plants; but the amount of material at my disposal proved insufficient for the purpose. I hope, however, to be able to grow a considerable quantity during the ensuing summer, and to repeat the experiments.

The facts ascertained are, however, amply sufficient to prove that ammonium sulphocyanate acts as a powerful poison on these plants, notwithstanding the large proportion of ready-formed ammonia it contains, while its metamer thiocarbamide stimulates the growth of similar plants, and induces healthy development of all their parts, thus acting as a distinct plant food. Indeed if it were not that thiocarbamide tends to revert to the sulphocyanate after some time, the former might be regarded as a good organic manure for tobacco.

I must leave to the vegetable physiologist the task of determining the precise way in which nutrition is arrested by the sulphocyanate, and promoted by thiocarbamide: for the present I am content to have shown that their effects on the particular plants employed are widely different, though the bodies compared contain the same elements chemically united, in the same proportions within molecules of the same weight. The conclusion is inevitable that their strongly contrasted physiological action is due to diverse molecular structure. We thus learn—

1st—That the particular elements of which the bodies are composed exerted less influence on their physiological activity than the intra-molecular grouping of the component atoms.

2nd—That, in some instances at least, differences of physiological activity between metameric bodies can be easily detected with the aid of plants.

LXXXIV.—A NEW DETERMINATION OF THE CONSTANT OF PRECESSION. By J. L. E. DREYER, PH.D.

[Read, June 26, 1882.]

AMONG the various constants of Astronomy one of the most important is the Constant of Precession. It is remarkable how few determinations of the exact quantity of this constant have appeared during this century, considering the great number of investigations called forth by the progress of Astronomy. Not counting theoretical researches on the subject, such as those of Laplace, Leverrier, Lehmann, and Stockwell, which possess great interest, but cannot, as regards accuracy, compare with those deduced from observations, we have in reality only three recent determinations of the Constant of Precession, by Bessel, Struve, and Nyrén. My reasons for undertaking a new determination will be best described by giving a rapid sketch of the researches of these three astronomers.

Bessel founded his investigation[1] on about 2400 stars which occurred both in Piazzi's Catalogue and in the catalogue which he had himself deduced from Bradley's observations. As the epochs of the two catalogues are 1755 and 1800, he thus found for 1777·5 the value of the two constants commonly designated as m and n, with which the variation of the right ascension (a) and declination (δ) of a star is computed by the well-known formulæ

$$\frac{da}{dt} = m + n \tan \delta \sin a,$$

$$\frac{d\delta}{dt} = n \cos a,$$

and from m and n the constant of the "General Precession." The result thus found was some years after modified by applying certain corrections to Bradley's and Piazzi's Right Ascensions, which were made necessary by the better value for the Constant of Nutation which Lindenau in the mean time had produced, as also by the two Fundamental Catalogues for 1815 and 1825, deduced from the Königsberg observations. Bessel's modified result for the year 1800 is[2]

$$50''\cdot 2235.$$

Otto Struve used for his determination[3] a very small number of

[1] Fundamenta Astronomiae, p. 285, *et seq.*
[2] Astronomische Nachrichten, vol. iv. (1826).
[3] Mémoires de l'Académie de St. Pétersbourg, 1842.

stars, only 400, but these had been most carefully observed in Dorpat from 1822 to 1838, and the resulting positions could be compared with Bradley's positions for the epoch 1755. The interval between the two epochs was thus considerably longer than in the case of Bessel's investigation, and this is a great advantage, as any error in the adopted equinoxes will thus be divided by a larger quantity and become less detrimental. But it detracts greatly from the value of Struve's result, that he has used such a small number of stars. It is easy to see that, if we use a large number of stars, we have to a great extent a right to suppose them uniformly distributed over the celestial sphere, and we may then safely neglect the influence of the proper motion of the solar system in space, as this influence on the stars in a certain part of the sky will be counteracted by the influence on the region diametrically opposite. But 400 stars are of course *not* uniformly distributed, and Struve was thus obliged to take the proper motion of the sun into account. This he did in a very beautiful manner; but as the amount of the apparent motion of a star, occasioned by the motion of the sun in space, depends on the distance of the star, Struve had to adopt his father's expressions for the relative distances of stars of the various classes of magnitude, and it will be conceded by everybody that these expressions are anything but certain. They depend on two hypotheses, neither of which are very well founded, viz., the supposition of a uniform distribution in space of the stars of the galaxial system, and the supposition that the apparent brightness of stars generally depends on their distance from us. Unfortunately the influence of the adopted system of relative distances on the final result is not inconsiderable. Struve's result, which is for 1800,

$$50''\cdot 2411,$$

has by degrees come into general use; but partly on account of the difference between it and Bessel's result, partly owing to the doubtful suppositions on which it to some extent depends, it must be considered very desirable to try by other means to deduce a new value for the Constant of Precession. This was done in 1869 by Dr. Nyrén of Pulkova, in a paper in the Swedish language,[4] but the value he found differed in a remarkable manner from the results of Bessel and Struve.

Nyrén adopted a new plan. Instead of using the brighter stars such as generally occur in Fundamental Catalogues, he chose the Right Ascensions of the large number of telescopic stars round the equator (between ± 15° declination) which could be found both in Weisse's Catalogue (deduced from observations made by Bessel in 1821-35) and in Schjellerup's Catalogue, founded on observations made by this astronomer in the years 1861–63. As the positions for these 5000

[4] Translated in the Bulletin de l'Acad. Imp. de St. Pétersbourg, 1870.

stars were determined with an interval of about forty years, with first-class instruments, and by eminent observers, and as Nyrén took special precautions to clear Bessel's positions of constant errors by comparisons with the Dorpat and Armagh Catalogues, the material thus prepared must be considered very promising for a good result. It was therefore very surprising that the comparison between Schjellerup's and Bessel's Right Ascensions showed a well-established difference $S - B = - 0^s\cdot135$, which, after reducing the equinoxes of the two Catalogues respectively to Wolfers' equinoxes for 1830, and to an equinox for 1862, deduced from Greenwich and Paris observations, did not become smaller than $- 0^s\cdot095$. This indicated a rather considerable correction to the adopted constant. Nyrén's final result was, for 1800,

$$50''\cdot1882.$$

The deviation of this result from Bessel's and Struve's is very much larger than the accuracy of modern observations should lead one to think possible. In my Paper on the personal errors in transit observations (these *Proceedings*, ser. II., vol. ii., p. 518) I have mentioned a fruitless attempt to find out whether either Bessel's or Schjellerup's Right Ascensions show any sign of errors depending on the magnitude of the stars, as such an error, if it existed, might explain the difference between the constants of precession found from bright and from faint stars. But although it turned out to be impossible to find directly whether the personal errors of Bessel and Schjellerup depended to any sensible extent on magnitude, there are many circumstances which must lead us to believe that this was *not* the case. Argelander has compared Bessel's Right Ascensions with those of W. Struve ("Positiones Mediæ"), and found $S - B = - 0^s\cdot043$; but as the reduction of Struve to Wolfers' Fundamental-System is zero, while Bessel's is $- 0^s\cdot012$, the difference between Wolfers' (*i.e.* Bessel's Fundamental Catalogue) and Bessel's zones would only appear to be $- 0^s\cdot031$. As to Schjellerup, we possess a comparison between his catalogue and that deduced by Copeland and Börgen from their observations of stars between the equator and $-2°$ declination; and as these observers used the same standard system (Nautical Almanac), the result, C and $B - S = - 0^s\cdot005$, leaves scarcely any doubt that Schjellerup's Right Ascensions are free from constant errors.

Nyrén's result must therefore be affected by some considerable errors in one of his equinoxes, and a later investigation by himself has, in fact, shown conclusively that the observations of the sun, made in Greenwich (and on which his equinox for 1862 chiefly depended), require a large positive correction to make them agree with the observations made at Pulkowa, Edinburgh, Cambridge, Paris, and Washington; and their fair accordance with the Paris observations of 1856–59 must be due to the chapter of accidents. But it is evident that this positive correction will do away with the greater part of the large difference between Schjellerup and Bessel, and consequently

Taking the mean of all the differences for each hour of Right Ascension, I found—

0^h	Schj.–Lal. =	+ 0^s·099	from	133	stars.
1		+ 0 ·073	,,	72	,,
2		+ 0 ·092	,,	80	,,
3		+ 0 ·143	,,	142	,,
4		+ 0 ·106	,,	121	,,
5		+ 0 ·051	,,	108	,,
6		+ 0 ·059	,,	128	,,
7		+ 0 ·077	,,	112	,,
8		+ 0 ·042	,,	125	,,
9		+ 0 ·024	,,	135	,,
10		+ 0 ·034	,,	117	,,
11		– 0 ·014	,,	132	,,
12		– 0 ·055	,,	156	,,
13		– 0 ·023	,,	115	,,
14		+ 0 ·032	,,	107	,,
15		– 0 ·009	,,	137	,,
16		+ 0 ·055	,,	149	,,
17		+ 0 ·076	,,	145	,,
18		+ 0 ·042	,,	185	,,
19		+ 0 ·036	,,	176	,,
20		+ 0 ·043	,,	207	,,
21		+ 0 ·050	,,	174	,,
22		+ 0 ·062	,,	140	,,
23		+ 0 ·006	,,	169	,,

As will be seen from the number of stars within each hour, the stars are not quite as uniformly distributed as might have been wished, there being a minimum at 1^h–2^h, and a maximum at 19^h–20^h. But as these hours must rather be considered as exceptional, and as the single differences within 1^h and 2^h agree well *inter se* and with the majority of the remainder, there is no reason to give these hours less weight than the rest. It is not without interest to notice the prevalence of the plus sign around 3^h, and of the minus sign nearly diametrically opposite. This agrees well with the direction of the motion of the solar system through space.

The mean result of the 24 hours is—

$$\text{Schjellerup–Lalande} = + \; 0^s{\cdot}0459 \pm 0^s{\cdot}0061.$$

From this difference we have now to separate the quantities depending on the constant errors of the fundamental systems, *i.e.* of Piazzi's Catalogue and the Nautical Almanac. It appeared advisable to reduce these to Newcomb's above-mentioned standard system, which is probably sensibly free from systematic errors; besides, I could thus make my final result directly comparable with Newcomb's corrected values.

The correction to Piazzi is + $0^s \cdot 100$, and that to the Nautical Almanac for 1861–63 is + $0^s \cdot 073$: the difference becomes then—

$$\text{Schjellerup–Lalande} = + \; 0^s \cdot 019 = + \; 0'' \cdot 285.$$

This quantity must now be considered as arising from an error in the adopted value of the constant m; and as the interval between the mean dates of the two series of observations was found to be exactly 66 years, we have for 1829·7 (the mean of the two epochs),

$$\Delta m = + \, 0'' \cdot 0043.$$

This correction has now to be added to the mean of the two values of m which were used for computing the precessions for 1800 and 1865. This is

$$m = 46'' \cdot 06225,$$

and consequently the new value is (for 1829·7),

$$m = 46'' \cdot 0666.$$

In order from this to determine the Constant of Precession for the epoch 1800, I adopted the values of the planetary precession, the difference between the lunisolar and general precessions, and of the obliquity of the ecliptic, given by the late Professor Peters in his memoir "Numerus constans Nutationis," and found for 1800 + t:

$$\text{Lunisolar Precession} = 50'' \cdot 3752 - 0'' \cdot 0002168 \, t.$$

$$\text{General Precession} = 50 \cdot 2365 + 0 \cdot 0002268 \, t.$$

$$m = 46 \cdot 0581 + 0 \cdot 0002849 \, t.$$

$$n = 20 \cdot 0589 - 0 \cdot 0000862 \, t.$$

The new value of the Constant of Precession, $50'' \cdot 2365$ for 1800, is only $0'' \cdot 0046$ smaller than the value now in use in all the great astronomical Ephemerides, and the confirmation thus given to Struve's value is of importance, when we remember the uncertain foundation on which the latter rests. That my result is entitled to some weight cannot be doubted, as it depends on more than three thousand stars observed most carefully with an interval of 66 years. The result is also interesting as showing that the fainter stars, down to the ninth magnitude inclusive, are not distinguished by any common and rotatory proper motion, such as would reveal itself by their giving a different value for the Constant of Precession from that given by the brighter stars.

LXXXV.—Multiple Renal Arteries. By A. Macalister, M.D., F.R.S., Professor of Anatomy, University of Dublin.

[Read, June 26th, 1882.]

Irregularities of the renal arteries are the commonest varieties met with among the abdominal vessels; indeed these arteries present some form of variation in three cases out of every seven.

Leaving out of account those varieties which are associated with misplaced, or horseshoe kidneys, we may classify the many forms of anomalous renal arteries as follows:—

1. *Varieties of Numbers.*—The arteries may be—(*a*) diminished in number, and this under two conditions—(*a*), with absence of the left kidney, as in Weissman's case;[1] or (*b*), with the origin of both renals from a common stem arising from the front of the aorta, as in Portal's well-known instance. Very much more commonly (β) the arteries are increased in number.

Multiple renal arteries may be threefold—(*a*), Most commonly the additional branches spring from the aorta; (*b*), or they may come from other sources; or (*c*) there may be a co-existence of additional vessels from both sources.

Of the first class, there have been described cases of,

one, two, or three	right aortic renals associated with	one, two, three, or four	left aortic renals.

Of these twelve varieties, I have not found the variety of two right and four left, and I have seen, in addition, single instances of three right and five left, and three right and six left. The commonest form, next to the normal condition of one on each side, is two on the right and one on the left. The second commonest condition is the reverse; but among the forms with larger numbers the greatest number is more frequently seen on the left than on the right side. In all these cases one vessel arises in the position of the normal renal; a second commonly springs from the aorta much lower down, generally on the level of, or below, the inferior mesenteric; the third, when present, is a very short distance above the normal renal, very close to the supra-renal, and on the level of the superior mesenteric (this branch is not to be confounded

[1] In cases like those described by Hunter (Med. Trans. of the London Coll. of Physicians, vol. iii. 1785, p. 250), and by John Reid (Phys. Path. and Anat. Researches, p. 417), where there were *two* kidneys on the right, and *none* on the left, there were two right renal arteries, an upper and a lower, and none on the left. For other cases, see Edin. Med. Journal, July, 1879.

with the form, to be hereafter noticed, of a renal branch from the supra-renal). These multiple branches have been described by most anatomists, so I need not give references. Cases of five on the right are described by Otto and Meckel, and other multiple forms are recorded by many of the older anatomists.

2. *Varieties of Origin.*—Additional renals often spring from other sources, in the following order of frequency :—(α), The supra-renal, a very common source of an upper renal artery; (β), the second, or (γ), the third lumbar artery; (δ), the right hepatic; (ϵ), the colica dextra; (ζ), the external iliac; (η), the internal, or (θ), the common iliac; or (ι), from the middle sacral. Of all but the first I have seen but single instances. Parallel cases, however, are quoted by Otto, who has seen two instances of the last form where the anomalous branch went respectively to the right and to the left kidneys. Otto also records a curious and unique example, in which a branch from the right common iliac supplied the left kidney.

The most remarkable instance of this class of variety which I have noted is one which I have preserved in our University Anatomical Museum, taken from a male adult subject.

In this case, on the right side, there are three renals, two from the aorta, a normal, and an inferior, and one from the capsular artery. There is no capsular branch of the aortic renal on this side. On the left side there are six renals from the following varied sources :—three from the trunk of the abdominal aorta, a normal, an inferior, and a superior, which arises directly below the left aortic supra-renal, and sends an inferior capsular branch to that organ, and enters the superior extremity of the kidney. The normal renal bifurcates before it reaches the hilus.

A fourth renal artery springs from the front of the aorta, immediately above its bifurcation, and with its origin a little to the right of the middle line. If this origin were a quarter of an inch lower it would be comparable with Otto's otherwise singular instance above quoted. The fifth renal arises from the sacra media, about half an inch below the origin of that vessel, crosses over the left common iliac artery underlying the ureter, and entering the lower part of the hilus of the kidney. The sixth and lowest branch arises from the internal iliac artery immediately at its point of division, ascends, crosses the common iliac, and pierces into the lower part of the gland. This instance is thus remarkable as combining in itself three of the rarest forms of anomaly hitherto described.

3. Anomalies of branching of the renals are very common; indeed, the number of branches whereby the normal renals enter the substance of the kidney is very inconstant; three or four are the commonest numbers, but I have seen up to ten penetrating branches. I have, however, preserved no record of the relative frequency of these. Otto describes the renals in one case as branching into very many branches. The other extreme, that is, the entrance of the renal by a single branch into the glandular substance, is rarer than multiple division.

4. *Varieties of Entrance.*—The places where renal arteries enter the kidney vary. Usually—(*a*), all enter at the hilum; (β), one often enters at the lower end, and this in most cases comes from the aorta, but may be a branch of the normal renal, once from the lumbar; (γ), one may enter at the upper end, most commonly a branch of the supra-renal, but which may be from the aorta or normal renal. I have seen a vessel piercing into the front surface of the gland from the normal renal; and in another case a posterior branch passed under the inner edge of the gland, and entered the gland at the middle of its posterior surface.

5. *Varieties of Distribution of Branches.*—From the renal there may arise branches—(*a*), to the supra-renal capsule, very common if not normal; (*b*), to the diaphragm, once; (*c*), to the right crus of the diaphragm; (*d*), to the right colon; (*e*), to the pancreas, deep surface of the head; (*f*), to the testis, supplanting the normal spermatic; (*g*), to the right lobe of the liver. These anomalous branches, with single examples of which I have met, were all on the right side, which is curious, as the majority of the anomalies in Class No. 2 were sinistral.

In connexion with these anomalies, it is interesting that in one case of Oppolzer's anomaly, a floating kidney, where the organ was almost entirely surrounded with peritoneum, the vessels were normal, as in the case described by Urag (Wiener Medicinische Wochenschrift, 857, No. 42).

Multiplication of renal arteries is not surprising when we consider the arrangement of these vessels in other animals and their development. Thus for the elongated kidneys in fishes the arteries are numerous, and with a trace of metamerism in their succession. In the iguana and monitor, among lizards, they are also multiple, as also in snakes. The alligator and crocodile have three or four on each side. Most birds have four, five, or six pairs, of which the three uppermost arise from the aorta, and the two or three lowest from the ischiatic.

The mammalian kidney is the metanephros, or hinder part of the primitive excretory organ, and it originates from a rounded mass of mesoblast, from the intermediate cell mass at that region where the dorsal outgrowth from the Wolffian duct extends forward to the tissue behind and nearer the spine than the rest of the nephros. In this tissue the vessels originate *in situ* in the mesoblast, close to those which supply the abdominal wall. These vessels, which are thus close together, separate at an early period, though traces of this primitive relation persist in the extra-peritoneal anastomoses of the renal arteries, through their arteriæ adiposæ and capsular branches. We owe many of the anomalies above described to persistent accidental enlargements of some of these vessels.

observations have been made by Professors Henle and Mac
The *linea semicircularis Douglasii* which marks the level o
entrance of the deep epigastric artery within the sheath of the r
abdominis is regarded by Retzius and by Hyrtl as the margin
fold of the fascia transversalis, which descends from that lev
cover the posterior surface of the bladder. With the descripti
these distinguished anatomists I cannot concur, and prefer to r
the semicircular border as the lower edge of the aponeurosis o
transversalis united with the posterior lamella of that of the int
oblique, where they cease, to pass behind the rectus muscle.

Transversalis abdominis.—The costal attachments of this musc
twenty-nine of thirty-six cases, were six in number. In fou
attachment was to seven ribs; in the remaining three the numbe
reduced to five. Guthrie's description of the perforation of the
part of the muscle by the spermatic chord was verified by two
ples, and I have also seen two or three others. The reflected
described by Sir Astley Cooper as passing from the outer edge
conjoined tendon and reaching along Poupart ligament as far
internal ring, I have not found at all well developed in any
Only a few scattered muscular bundles can be found in the apo
tic process, which passes from the outer margin of the conjoin
don, along the posterior wall of the inguinal canal.

Rectus abdominis.—The variations of this muscle chiefly af
breadth, length, and number of tendinous inscriptions. The
opposite the umbilicus I have found to vary from two and a-
inches to three and three-quarters. I have traced some of the fib
sternal insertion in two instances. In one case I noticed that th
attachment of the muscle was to the cartilage of the fourth and fi

The number of tendinous inscriptions varies from two to fiv
being the usual proportion. They were specially examined i
cases. Of these, two presented absence of the xiphoid insc
those present being the umbilical and intermediate. I ha
observed this in two other subjects, in one of which the de
was bilateral. The intermediate inscription was absent in o
and I have noted two other instances. In one case observ
included in the above sixty) there were five lineæ transvers
being infra-umbilical. In five of the sixty cases one infra-u
inscription was present, the degree of development varying
The umbilical inscription was invariably present.

Doubling of this muscle on one side has been recorded b
but this must be excessively rare. In some emaciated sub
have sometimes found one or two segments easily separable into
three fasciculi.

Pyramidalis abdominis.—This muscle I have carefully exam
sixty subjects, In nine of these the muscle was absent on bot
In five subjects it was absent on one side only: in three of th
deficiency was on the left side; in two on the right. In six
subjects the left was obviously smaller than the right, the dif

length being from half to one inch. In one case a tendinous slip m the upper end of the fleshy fibres produced the insertion as far he umbilicus: the tendinous segment was in this case about one-d the whole length. It occurred on the right side. In one case a linous inscription was found to cross the muscle about its middle; levelopment was bilateral, and the inscriptions on the same hori-tal level. In another case, not included in the above number, I e seen a tendinous intersection on one side. The length of the cle varies within wide limits, and, in my experience, ranges from e more than one-fourth of the distance between the pubis and ilicus to two-thirds of that space. The breadth similarly varies n one-third of that of the pubic crest to the whole width of the er.

The muscle is, in some cases, easily separated into two or three iculi; but I do not think that these deserve the name of double, le, or quadruple pyramidales, such as have been occasionally ribed by anatomists, and from, I have no doubt, similar ap-rances.

Cremaster.—The only variation of this muscle which I have noted n origin almost wholly continuous with the lower fibres of the isversalis abdominis.

Pubo-peritonealis (Macalister); *pubo-transversalis* (Krause).—I e in one subject found a delicate band of muscular fibres, cor-onding in position to the anomalous muscle described under the ve name by Professor Macalister. It arose from the ilio-pectineal behind Gimbernat's ligament, and passed obliquely upwards ards the middle line, between the transversalis muscle and fascia, within two inches of the umbilicus. It passed in front of the deep gastric artery, and was inserted into the fascia transversalis.

Quadratus lumborum (*Scalenus lumborum* of Meyer).—According to Krause, the anterior portion of this muscle has normally an attach-t to the body of the twelfth dorsal vertebræ. This observation s not accord with my experience; but this vertebral attachment exist in eight, out of thirty specimens, in which it was specially ched for. The slip passed upwards and inwards in front of the lfth rib, and below and nearly parallel to the eleventh intercostal ve. In two cases (not included in the above number) I have nd a slip to the eleventh dorsal vertebra, and, in three instances, s to both eleventh and twelfth co-existed. In one subject a slip ed to the lower border of the eleventh rib.

Levator ani (*levator intestini recti; diaphragma pelvis*).—This cle seldom presents any notable anomalies. An inferior slip of sional occurrence is mentioned by W. Krause, passing separately kwards to the anus, sometimes above the transversus perinaei rficialis, and, in other cases, above the transversus p. profundus. ve once seen a band of fibres answering to the description in the named position.

Coccygeus.—This muscle, the rudimentary homologue of the *m.*

abductor caudæ anterior of the canine tribe (W. Krause), presents great varieties in the degrees of its development. Three times I have found complete absence of the muscular fibres; in one of these the deficiency was bilateral, and tendinous fibres took the direction of the normal muscular bundles.

Sacro-coccygeus posticus; extensor coccygis; levator coccygis (Morgagni).—This bundle of muscular fibres I have found four times in thirty subjects. Once it was bilateral; once the origin was from the posterior inferior iliac spine; in the other cases it arose from the posterior surface of the third and fourth bones of the sacrum. W. Krause regards it as the homologue of the *extensor caudæ lateralis* of the dog.

Sacro-coccygeus anticus; curvator coccygis (the homologue of the *m. flexor caudæ* of the dog, according to W. Krause).—This band of muscular fibres passes from the fourth and fifth bones of the sacrum, along the front of the coccyx, nearly to the tip of the latter. I found muscular fibres twice in sixteen subjects, and in several others tendinous bands occupied the corresponding position. I have also met with these fibres in several other instances, but they were always very weakly developed.

Transversus perinaei superficialis (*s. posterior*).—This muscular band, which was first figured by Tiedemann (1822), is described by Lesshaft as an anomalous muscle of comparatively rare occurrence (9 per cent.) Krause has, however, found its occurrence much more frequent, and I have myself found it six times in thirty subjects in which it was searched for. I have also met it casually in many other dissections. It was regarded by Theile (1841) as an aberrant slip of the sphincter ani externus. This muscle lies between the layers of the superficial fascia, passing from opposite the inner margin of the ascending ramus of the ischium, or beneath the tuberosity of this bone, forwards and inwards to the central tendinous point of the perinæum. The muscle more generally known as the *t. p. superficialis* has been named by Lesshaft the—

Transversus perinæi medius.—This muscle lies between the deep layer of the superficial fascia (so-called fascia of Colles) and the anterior layer of the triangular ligament. According to Lesshaft, this muscle is absent in thirty-five per cent. of the cases examined. In thirty subjects specially examined by me the muscle was eight times absent, the deficiency being bilateral in five cases. In the others the degrees of development varied greatly.

Transversus perinæi profundus (*s. anterior*). (*Guthrie's muscle; ischio-bulbosus*).—This muscle is placed farther forwards than that already named, and is separated from the anterior margin of the levator ani by the deep layer of the triangular ligament. The degree of development varies greatly, and it was completely absent three times in thirty bodies.

Gluteo-perinealis (Krause).—This band of muscular fibres, passing from the fascia over the inner margin of the gluteus maximus (oppo-

site the tuberosity of the ischium) to the central tendinous point of the perinæum, I have twice observed. It is a variety of *transversalis perinæi superficialis*.

Levator urethræ; pubo-urethralis; Wilson's muscle.—This muscle is now properly regarded as formed by the anterior fasciculus of the levator ani muscle. It is a small band (usually about 1 mm. in breadth), which arises about 1 cm. outside the margin of the symphysis pubis, and about the middle of its level, and passes downwards and backwards to the central tendinous point of the perinæum. It was absent five times in thirty subjects examined, the deficiency being bilateral in all cases.

Psoas magnus.—This muscle was examined on both sides in forty subjects. Some variations of origin were observed. In three instances some fibres took origin from the neck of the last rib; this peculiarity was symmetrical in two of the cases. Fibres of origin came from the lateral margin of the right crus of the diaphragm in one of these, and I have notes of three other cases in which the same was observed. An origin from the left crus I have once met with.

The origin from the last lumbar vertebra was deficient in five bodies. In three this occurred on both sides; in the other two it was unilateral, the deficiency being on the left side in both cases.

Psoas parvus.—This muscle was present in seven of the forty subjects. In five of these it was bilateral; in the other two on the right side only. The origin in all cases was as described in the ordinary text-books.

A case of psoas parvus having the usual origin, but inserted into the side of the cartilage between the third and fourth lumbar vertebræ, has been already published by me in these *Proceedings*.

Sartorius.—A case of insertion into the inner side of the capsule of the knee-joint has been already recorded. A well-marked separation between the spinous origin of this muscle and that from the interspinous notch I have four times noted. In three cases the chink transmitted a considerable branch from the ascending division of the external circumflex artery.

Quadriceps extensor cruris; rectus (externus) femoris.—Slight variations in the tendons of origin or insertion of this muscle are not unfrequent. In forty specimens, carefully examined, three presented direct continuity of the acetabular and spinous heads of origin. In one case, a small accessory tendinous slip came from the anterior superior spine; in two there was a division of the spinous origin of the muscle into two parts, separated by a thin layer of areolar tissue.

In one of the cases enumerated above, and in three others which I have from time to time observed, the tendon of insertion was covered in front, by the overlapping of the vasti tendons, which, with the cruræus, formed a canal, through which the former tendon passed to the patella.

Vasti muscles; *cruræus.*—The variations of these muscles were

almost entirely limited to the size and extent of femoral attachments, and presented but little interest. The vasti I have sometimes found bilaminar, and this is, I think, more frequent than is usually supposed: I have noted five cases of this arrangement in the internal, and three in the external muscle; and also met with several others of which I made no record.

The sub-cruræus was absent in three of the forty limbs examined.

Adductor longus.—This muscle was divided into two lamellæ along its whole length, in three cases of which I made notes. One of these was among the forty of which the femoral muscles were specially examined. In cases recorded by Wood and by Macalister this muscle received a slip from the pectineus, which joined the former by crossing in front of the profunda femoris artery. A muscular fasciculus passing to the inner side of the vastus internus, by crossing in front of the aponeurotic sheath, which forms the anterior wall of Hunter's canal, was found in one case.

Adductor brevis.—In a considerable proportion of the cases examined this muscle could, with considerable ease, be separated into two portions, the line of division being marked by the passage of a perforating artery. Clason (Upsala lakaroforen forhandl. 1872, vii. 599) describes the muscle as being separated in this way into two segments—a superior, somewhat transverse, adducting part, and an inferior portion, more vertical in direction, and chiefly concerned in the act of flexion.

Adductor magnus.—The only notable variety I have found in this muscle is the complete separation of the segment which goes to the inner condyle of the femur. This I have noted in three instances, of which only one occurred among the forty above referred to.

Adductor gracilis (*rectus femoris internus*).—This muscle rarely presents any considerable degree of deviation from the description usually given in our text-books. Tendinous fibres are sometimes formed about the junction of the middle with the lower third of the thigh, which blend with the fascia lata, after a very short course. This I have noticed in four instances.

Pectineus.—The portion of the fibres of this muscle which arise from the ilio-pectineal eminence occasionally form an accessory head of origin separate from the rest of the muscle. This happened once among forty specimens consecutively examined, and I have also noted its occurrence in two other instances. A few of its outer fibres I have once seen inserted into the front of the hip-joint capsule.

Gluteus maximus.—A thinner deep lamina, formed by those fibres of the muscle which arose from the great sacro-sciatic and posterior sacro-iliac ligaments, was separated from the superficial part of the muscle by a distinct layer of connective tissue. This occurred five times in forty subjects examined. In three instances the origin of the muscle reached to the second coccygeal vertebra only; in all the others there was the usual attachment to the third piece. An acces-

sory slip of origin from the lumbar aponeurosis occurred in two of these. This I have also noticed in three other instances.

Gluteus medius.—In five cases the anterior edge of this muscle adhered intimately to that of the minimus. A bond of union between the anterior edge and that of the gluteus minimus, with the fascia lata, is formed by the ligamentum suspensorium ossis femoris of Günther (ligamentum suspensorium trochanteris of Henle). When well developed, this band is about seven centimetres in breadth, and reaches from the outer lip of the iliac crest to a little below the trochanter major.

Gluteus minimus.—This muscle I have twice seen pierced by the gluteal vessels and superior gluteal nerve. In one of these the inferior segment was adherent to the pyriformis for the greater part of its length.

Gluteus accessorius.—A deep inner lamina of gluteus minimus passing with the tendon of the latter to its insertion, and separated from it by a thin layer of areolar tissue. Three specimens noted.

Gluteus quartus; scansorius; invertor femoris.—This name has been given to a differentiated anterior segment of the gluteus minimus, which stretches forwards and upwards to the anterior superior spine. The specimens of this anomalous muscle which I had noted were placed on record last year. It was met with once last winter, in which case the occurrence was symmetrical, the insertion being on one side into the trochanter major with that of gluteus minimus, and on the other partly into the trochanter, and partly to the side of the vastus externus.

Pyriformis.—This muscle varies a good deal in the degree of its development, but I have never met with a case of complete absence, such as has been described by Budge and by Macalister. I have noted two instances in which the sacral digitations were reduced to two. Both had been the subjects (on the corresponding side) of chronic rheumatic arthritis. The iliac origin (at upper border of great sacro-sciatic notch) was twice in forty cases separated by a distinct areolar layer from the sacral portion of the muscle. The superior gluteal nerve perforated the upper part of the muscle in one case. The splitting by the great sciatic nerve occurred three times in forty lower limbs; once it was bilateral.

Gemellus superior.—This muscle I have found absent in a considerable number of instances. Once I found its fibres joining the tendon of pyriformis, instead of that of obturator internus. In three cases dissected by me the muscle could easily be separated into two parts.

Gemellus inferior.—During the last winter session I noted for the first time two instances of the absence of this muscle. I have several times found the muscle easily divisible into two or even three fasciculi. Two cases have also been noted in which connecting fasciculi passed from this muscle to the adjacent margin of the quadratus femoris.

Obturator internus.—Slight variations in the field of origin of this

muscle are not infrequent, but they seldom amount to marked peculiarity. The most remarkable I have met with is an origin from the anterior surface of the great sacro-sciatic ligament, close to the lesser sciatic foramen. This I have seen three times. In one case the accessory slips formed a fleshy band of about three-quarters of an inch in width, and about a line and a-half in thickness. The others were hardly half so large. A distinct slip, arising from the inner surface of the ischium, above the level of the spine, was present in two subjects examined, and the slip was symmetrically developed in one case.

Obturator externus.—This muscle is very frequently divided into two layers by the obturator vessels and nerve. This division occurred in four of twenty cases consecutively examined; the upper smaller portion taking origin from the horizontal ramus of the pubis. In a somewhat smaller proportion of subjects a very intimate degree of adhesion of the tendon to the capsule of the hip-joint was noticeable.

Quadratus femoris.—Two cases of absence of this muscle have been already published, as mentioned under the head of gemellus inferior. I have found fibres of connexion passing from the latter muscle into the upper edge of the quadratus. In three cases an accessory bundle of muscular fibres took their origin from the tendon of the semimembranosus, and a similar variety has been noticed by Mr. Kelly of this city (quoted by Macalister). The lower border I have occasionally found very closely adherent to adductor magnus.

Semi-membranosus.—The tendon of origin was observed in three cases to consist of two completely distinct parts. In one the peculiarity was bilateral. A slip of insertion to the retinaculum ligamenti arcuati has been noticed by Macalister, and I believe it to be of pretty frequent occurrence, as I have observed it in a good number of cases. A distinct slip to the fascia of the leg, forming a *tensor fasciae suralis*, is mentioned by W. Krause. Of this I have met with one example.

Semi-tendinosus.—This muscle rarely presents any notable variety. The tendinous inscription I have in one case found to be doubled; in a large number of cases it was interrupted, but never completely absent.

Biceps flexor auris.—I have already published two cases of absence of the short head of this muscle. An accessory head arising from the upper part of the linea aspera has also been recorded, and since its publication I have met with two other specimens of three-headed biceps; the accessory head arising, in one case, from the upper part of linea aspera, and in the other from the internal condyloid ridge of the femur.

Of the variations of the tendon of insertion I have noted four examples of a slip to the outer tuberosity of the tibia. A tendinous band of three-quarters of an inch in breadth, passing to the tendo Achillis, came under my observation in one case: the subject had been a very muscular one.

Tensor fasciæ suralis.—A slip from the biceps to the fascia, over

the muscles of the calf, sometimes occurs, and has been described under this name. I have observed such a slip in two cases; in one it was bilaterally developed.

Tibialis anticus.—The origin of this muscle rarely presents any considerable variety. I have twice observed an accessory bundle of muscular fibres from the head of the fibula. The insertion is not so constant. Of thirty cases examined, two sent each a slip to the ligamentum cruciatum; in two others a slip was sent to the inner side of the head of the first metatarsal bone: one was found to send a process to the base of the first phalanx of the great toe. The slip to the ligamentum cruciatum is present, according to Professor W. Krause, in six per cent. of the cases examined.

Tibio-fascialis anticus (Wood); *tibialis anticus accessorius* (*s. profundus*); *tensor fasciae dorsalis pedis* (W. Krause).—Of this muscular slip I have met with two examples in forty cases consecutively noted. It was in each case united to the tibialis anticus at its origin, and the insertion was partly into the annular ligament and partly into the deep fascia on the dorsum of the foot.

Extensor proprius hallucis.—The only variety of this muscle which I have noted was a slip from its tendon to the innermost tendon of the extensor brevis digitorum. This I have observed in four instances.

Extensor digitorum longus.—The tendons of this muscle were specially examined in thirty cases. Two of these presented a slip to the innermost tendon of extensor brevis digitorum, which proceeded with it to the base of first phalanx of great toe. Two others sent slips to base of first phalanx of second toe. In one case a well-marked slip passed from the outermost tendon to the dorsum of the fifth metatarsal bone about its middle. Two sent slips to the base of this bone. In another case two slips were sent from the third and fourth tendons to the bases of the fourth and fifth metatarsal bones respectively.

Extensor hallucis longus accessorius (*s. minor*); *extensor primi internodii hallucis.*—This muscle is of very frequent occurrence, so that it is regarded by some observers as a normal structure. It was found by Professor Wood in nearly half the subjects which he examined, and other observers have recorded a proportional frequency of as much as eighty per cent. I have found a muscular slip, more or less completely continous at its origin with the lower part of the extensor proprius pollicis, and proceeding to the base of the first metatarsal bone—in sixteen cases of forty in which it was specially searched for. In four cases a slip having the same insertion came from the tendon of proprius pollicis, and in one from the innermost tendon of longus digitorum.

Peronæus longus.—This muscle I have found inseparably adherent to the brevis in three instances. In two cases I observed a tendinous slip to the base of the fifth metatarsal bone, to which it adhered, even below and behind the tendon of insertion of the peronæus brevis. In another case a slip passed forward to the under surface of the head of the first metatarsal bone. Expansions from the tendon to the bases of the third

middle of the fibula between the long and short peronæi.

Peronæus brevis.—In the origin of this muscle I h no marked peculiarity except that of origin, as mentioned head of peronæus longus. In a good many cases a tendious tion was given to the origin of the short flexor of the litt slip to the extensor tendon of the little toe was present si forty. In each case it arose either opposite to the external or immediately in front of it. A slip of corresponding ori one case united with the tendon of the fourth dorsal interosseo and in another was found to be inserted into the dorsum o metatarsal bone about its middle.

Peronæus quartus.—Of this muscle I have already recor currence of two specimens. I have since met with a thir similar attachments to the others, but larger. In this ca sented the additional peculiarity of sending a second ten outer surface of the os calcis behind the insertion of the o analogous structure has been described by Professor W. Kr

Peronæus quintus.—Having a similar origin to that of t last described, and joining the tendon of extensor digitorum little toe. One specimen came under my notice last session.

Extensor brevis digitorum.—Twice in forty cases I found t give a delicate tendon to the little toe, joining the expans common extensor. In one of these the tendon to the gre absent, and I have noted this peculiarity in several other ins two cases a small slip was sent to the tendon of the fou interosseous muscle: one to that of the third, and one the first, have also been noted—a single example of each.

Indicator pedis.—An independent muscular band, arisin dorsal surfaces of the astragalus and scaphoid bones; and in the extensor tendon for second toe. This I have twice met

Gastrocnemius.—Accessory fibres of origin of this muscl external lateral ligament of the knee-joint have been a corded (five examples).

Gastrocnemius tertius.—This accessory third head of gast has come twice under my notice during last session. One aro

according to Krause. In one case I found this muscle arise from the back of the head of the fibula. An accessory head from the ligament of Winslow I have found in a considerable proportion of cases, and one from the planum popliteum of femur has been noticed in another instance. The latter was of considerable size (about one-third that of the normal head of origin).

Plantaris minor (Krause); *popliteus superior s. minor* (Calori.)—When the accessory head of the plantaris is completely separate, these distinctive names have been applied to it.

Soleus.—The soleal lamina of the tendo Achillis I once found quite distinct down to its insertion. A bi-laminar fibular head was noted in three instances, the lower lamina being the smaller in each case.

Tensor fasciæ plantaris.—A muscular lamina of about three-quarters of an inch in breadth, arising from the linea poplitea of the tibia below the soleal attachment, and passing down, superficial to the inner annular ligament, to be inserted into the plantar fascia. Of this muscle I met with one example. In another subject a muscle of similar origin was inserted into the ligamentum lanciniatum.

Poplitæus.—In one case I found a small sesamoid bone in the tendon of the poplitaeus, and its development was bilateral. A double muscle once.

Poplitæus minor.—An accessory bundle of fibres arising from the outer tendon of the gastrocnemius. Found present on two occasions.

Flexor digitorum longus.—The astonishing irregularity of the arrangement of the tendons of this muscle, and of its connexion with other tendons, has been conclusively shown by Professor Turner; also by the tabulated observations of F. E. Schultze, Wood, &c. As my own observations closely agree with those of the distinguished anatomists whom I have named, I did not tabulate them.

Flexor digitorum longus accessorius.—One example of this muscle I found arising between the lower part of the usual flexor and the tibialis posticus, and, passing into the sole of the foot, divided into two slips, which joined the tendons of second and third toes. In another case it assumed the form of a

Flexor digiti secundi proprius.

Flexor digiti minimi accessorius.—A muscular slip arising from the under surface of the tendon of the common flexor before its division, and going to the little toe. Its tendon is pierced in the thecal sheath by the corresponding tendon of the flexor brevis digitorum.

Tibialis posticus.—This muscle I have seldom found to present variations of striking interest. The tendon of insertion I have noticed in three instances to send a well-marked slip to the inner tendon of the flexor brevis digitorum. An insertion into the cuboid bone has been described as an anomaly, but this will be found to be present in the majority of cases, if searched for with sufficient care.

Flexor hallucis longus.—The origin of this muscle I have found very constant. The slip given from the tendon of this muscle to that

of the flexor digitorum longus I have found absent in two instances. Thrice I have noted the presence of a tendinous slip to the second toe, which was pierced (within the thecal sheath) by the corresponding tendon of the flexor longus digitorum. In a considerable proportion of cases (twenty-two per cent., according to Krause) one or more slips may be traced to the tendons of the lumbricales.

Tibialis secundus (Bahnsen); *tensor capsulæ tibiotarsalis; tensor membranæ synovialis tarsi.*—This anomalous muscle I have found present in two cases only. The degree of development was very different in the two. Arising in either instance from the posterior surface of the tibia below the tibialis posticus, the insertion in one case was into the ligamentum lanciniatum; in the other, into the posterior surface of the capsule of the ankle-joint.

Accessorius ad calcaneum.—This muscular slip has an origin similar to that of the muscle last described. The insertion in one specimen which I examined was into the posterior part of inner surface of calcaneum.

Pronator pedis.—One example of this muscle has been already published. I have not met with any other.

Interossei pedis.—Of the varieties of the plantar set, I have noted the following:—Four present in one instance, the additional one arising from the outer side of the great toe, and inserted into the corresponding side of the base of its first phalanx; the first plantar having an accessory head from the second metatarsal bone, and a perforating artery passing between the two heads; the outer plantar having an accessory head from the sheath of the canal for the peronæus longus.

Of the dorsal set, I have found the fourth arising by a single head in one instance; the only other peculiarities I have seen were of size and extent of osseous attachment, of which a great variety exists.

Abductor hallucis.—In three cases I have found a small tendinous slip going to the second toe, and attached to the inner side of the base of its first phalanx. The frequency of the presence of this additional band is nine per cent., according to Krause. I once saw a large slip go to the tendon of the flexor hallucis longus, with which it became intimately blended.

Flexor digitorum brevis.—The tendon for little toe was absent three times in thirty cases, in which this muscle was specially examined. Krause makes the frequency of its absence as much as fifteen per cent., and I have myself seen it in many other cases without making special note of the proportional frequency. In one instance a kind of substitute was present, formed by a tendon coming independently from a fleshy bundle, which was segmented from the lower part of the flexor longus digitorum.

Abductor minimi digiti.—An accessory head of origin to this muscle from the base of the fifth metatarsal bone I have twice met with. The tendon of insertion may be completely separate from that of the flexor brevis minimi digiti: this I have found in a good m[illegible]s. A tendinous slip to the base of the fifth metatarsal bone

nt in about sixty per cent. of the subjects examined by me. use regards its occurrence as normal; the frequency of its , which varies from twenty-five to fifty per cent., being greater emale. When this accessory slip has a distinct origin from the um, it forms an—

uctor ossis metatarsi minimi digiti.—This muscle I have found, enough to merit a separate description, three times in forty I have also noted its occurrence in a good many other in-

or digitorum accessorius; quadratus plantæ. Massa carnea Sylvii.—In four cases I have noted fibres of insertion going to lon of the flexor hallucis longus. In two of these, fibres were ched to the connecting slip given by the tendon of the flexor to that of the brevis digitorum. The origin I have, in several ound to reach to the upper surface of the os calcis, and once I ome fibres arising from the anterior surface of tendo Achillis.

bricales.—The only noteworthy peculiarity of this muscle have met with are the variations in number, which are not ent. The first (internal) muscle is that which I oftenest I have noted its absence six times, but without taking any of the relative frequency of the occurrence. I do not remem- ing observed absence of the third or fourth.

uctor pollicis.—A slip to the base of the first phalanx of great ve twice noticed. It came, in each case, from the inner por- the muscle (*caput obliquum*), and was of considerable size. or Krause describes, as a normal arrangement, the adhesion of sversus pedis to this muscle, giving to the portion formed by er muscle the name of caput transversum.

onens hallucis.—A fleshy segment sometimes separates itself e inner part of the adductor pollicis, and is inserted into the order of the os metatarsi hallucis. Some anatomists have usly regarded this slip as the homologue of the opponens .

nsversus pedis; transversalis pedis; transversus (s. transversalis) adductor transversus hallucis; abducteur transverse.—The ent of this muscle to the heads of the third and fourth meta- ones I have frequently found absent (five times in thirty-four The whole muscle was absent in another of the number, and noted three other instances of its deficiency.

LXXXVII.—Report on a Journey among the New Zealand Glaciers in 1882. By Rev. W. S. Green, M.A. (With Plate XVIII.)

[Read, June 26, 1882.]

The whole of New Zealand consists of a line of upheaved stratified rocks, modified in the northern portion by recent volcanic activity, and in one or two other places showing traces of more ancient vulcanicity. The axis of elevation runs from S.W. to N. E., and is cut across into the North Island, South Island, and Stewart's Island, by Cook's and Foveaux' Straits. In the South Island the mountains attain to their greatest elevation, and for over one hundred miles the Southern Alps, as they were named by Captain Cook, raise their peaks far above the snow line, in no place for the whole of that distance descending to a col or pass free from eternal snow and ice. Immense glaciers fill the valleys, and the remains of still more gigantic glaciers are everywhere to be met with.

This chain, with its continuation north and south, seems to have been upheaved in Jurassic times, and though it has experienced many vicissitudes of upheaval and depression it has never since, according to Professor Hutton, been submerged. These mountains are then of vastly greater antiquity than their European rivals, and their long exposure to the frosts and storms of ages is abundantly evidenced by the heaps of loose splintered stones to which all except the higher peaks have been reduced.

The mountains lie close to the west coast; their western flanks possess a humid climate (the rain-fall at Hokitika being measured at 118 inches), and are clothed with forest and impenetrable scrub. The western glaciers in some places descend to within 670 feet of the sea, and the rivers are short and swift. This low descent of the glaciers and the mean line of perpetual snow being at about 5000 feet compared with 8000 in Switzerland, where also no glacier descends to within 4000 feet of the sea, is particularly instructive, when we consider that these Southern Alps are at about the same distance from the Equator as the Pyrenees and the city of Florence. To the east of the mountains the land drops suddenly to a level of about 2000 feet above the sea, and then by gentle slopes and immense flat bare plains sinks gradually to the coast. The continuity of the plains is broken by ridges of low rounded hills, which on close examination often prove to be old moraine accumulations; while many of the plains are the basins of ancient lakes, the old shores being very sharply defined. In the southern and northern portions of the South Island the arrangement of mountains and plains is considerably modified by the splitting up and bifurcation of the main axis of elevation, but flat plains extending to the very foot of the highest peaks of the main chain are most characteristic of New Zealand, and totally unlike other mountainous countries, where ranges

foot-hills have to be ascended and upland valleys traversed before higher ranges can be reached. In the province of Canterbury, ere the mountains attain their greatest height in Mount Cook or Rangi, as it is called in the Maori tongue, these features are most inctly observable, the Canterbury plains followed by the Mac-zie plains extending up to the very ice, and so flat that Dr. Haast he would undertake to drive a buggy the whole way from Christ-rch to the foot of the Tasman glaciers. We tried it with an press waggon and three horses, and nearly accomplished it. The ntry was level enough, but the boulders as we drew near to the ciers proved a little too much for a wheeled vehicle, and our waggon ded its days by being capsized in the Tasman river.

These New Zealand rivers have been a source of much difficulty colonial development. They are so swift and erratic in their courses at fords are dangerous and bridges difficult to construct. Once the vers leave the mountains there is nothing to keep them to one chan-el, as the plains, being composed of loose boulders and sand, are easily aten away by the swift streams swelled in summer by the melting of he snow. A river bed is therefore a broad sheet of gravel through hich a number of small streams wander and change day by day—hat was a main channel one day being quite a secondary stream in he lapse of a week or so. Much time was often spent in crossing one ver with the delays of searching for fords; but now that railways n north and south the problem has been solved on the most important ute by bridges, some nearly a mile in length. In the province of tago rich woods extend right across the island to the east coast, ving place in many districts, however, to immense plains covered ith tussock grass and spaniard or sword grass, except where the rmer has come and adorned the landscape with waving fields of heat. Farther north the great snowy chain seems to form a com-ete barrier to the moisture and vegetation of the west: the plains, lls, and valleys are all bare, as if shaven, and of the one uniform ownish-yellow hue. Clumps of flax (*Phormium tenax*) and isolated bbage trees (*Cordyline australis*) make the desolation appear more solate. The rain-fall is but 25 inches. The air is clear, bright, d exhilarating, and when we do penetrate into the furthest recesses the mountains, to the very brink of the glaciers, we at last come to rank vegetation brought into existence by the rains condensed by e cold ice peaks. Acclimatization has produced wonderful results New Zealand. On the great grassy plains, where the moa once lked majestically, the skylark is now the commonest of birds, the rrow threatens to become a plague, as the rabbit has done, and glish weeds seem determined to establish themselves and attain to rtility unexampled at home. Clouds of thistle-down fill the air, d sorrel usurps the ground prepared for oats and wheat. Amongst er interesting points brought out by this invasion of the vegetable gdom, one at least is worthy of special notice—the failure of red ver, while white clover thrives amazingly. In the neighbouring

island of Tasmania red clover grows well, and it is now believed that till the humble bee is introduced to fertilize the flowers red clover will not propagate itself in New Zealand.

On the 12th of last November I sailed from Plymouth for Melbourne in the Orient steamer "Garonne," having arranged with Ulrich Kaufmann and Emil Boss, both of Grindelwald, to follow me in the next ship. Unfortunately smallpox broke out in my ship, and between a delay at the Cape and quarantine at Melbourne I was not able to reach New Zealand and join my men till February 5th. Immediately on landing I received a kind telegram from Dr. Hector, and a letter from the Minister for Railways enclosing free passes on the New Zealand railways for myself and guides during our stay in the Colony. I lost no time in reaching Christchurch, where I spent an afternoon in Dr. Haast's company, he being the great authority on the topography of the Southern Alps; and next morning we started in the train for the south. On arriving at Timaru we had a delay of three hours before the train left by a branch line for Albury, and we occupied the time in purchasing provisions for our mountain journey. As we were assured that we could get sheep right up to the snows of Mount Cook, we took with us but a small supply of meat in tins. Flour, meal, bread, and biscuits, formed the bulk of our stores.

On reaching Albury by rail we hired a waggon and horses, and on the evening of the next day we got our first view of the great snowy range. The contrast between the brown, flattened downs over which we drove and the purple, ice-seamed peaks was most striking. Next morning we were up betimes, as we did not know how long our journey might be, and our driver was unacquainted with the country beyond this point. Our road soon lost itself in the rolling downs, so we walked on in advance pioneering the way, and thus before midday we reached the last swell overlooking the Tasman river. We had now to descend about 200 feet, and again came upon the track leading up the river bed. This river bed of the Tasman, over two miles wide, is a broad sheet of coarse gravel, through which the river meanders in countless channels, between which are often dangerous quicksands. We drove along over marshy flats, on which numerous seagulls had their nests (one of the young seagulls we afterwards met high up on the glacier, winging its flight over the snowy range to the west coast), then across river channels, and then over wide tracts of gravel. Right before us, rising abruptly from the river bed, in the point where the valley forked, was the great mass of Mount Cook, its icy peak glittering like a pinnacle of frosted silver against the deep blue sky. On either side the mountains rose from the flat valley with the same abruptness, and the terminal face of the Hooker and Tasman glaciers closed in the end of the two branches into which the valley divided to the right and left of Mount Cook. This flat river bed, with the mountains rising from it abruptly, and from margins as sharply defined as the shores of a lake, is so typical of all the mountain valleys we

saw, that we may ask, What is the cause of a feature so distinctive? I believe the low level to which the glaciers descend, and the consequent short incline of the rivers, is a sufficient cause. The terminal face of the Tasman glacier is, according to Dr. Haast, only 2456 feet above the sea; while the mean of four observations, taken in as many days by myself, makes it 100 feet lower; and its river descends to the sea level by a fairly uniform incline of about 25 feet to the mile. If the river had a greater depth to descend before reaching the level country or sea level, it would erode a deep ravine-shaped bed, like those so common in the European Alps. High up on the mountain slopes, on the side of the valley opposite to where we travelled, were the most remarkable series of terrace formations I ever saw, their level being quite 500 or 600 feet above the present river, and their edges sharply defined. Dr. Haast considers that they form part of the margin of an ancient lake, which was dammed up by a glacier crossing the valley lower down during the last great glacier period.

Accepting, in part, this interpretation of the phenomena, several interesting questions follow, which we shall try to answer: What river or rivers fed this lake? Was it the Tasman? The present source of the Tasman being about 200 feet lower than the terraces, would be below the level of the ancient lake, so that it could not have been the feeder, unless the lake existed in an inter-glacier period, when the climate was milder, the ice-cap smaller than at present, and the source of the Tasman higher up the valley. Supposing it was not filled by the Tasman river, it seems to follow that, at the time of the existence of the lake, the great trunk glacier formed by the junction of the Hooker and Tasman glaciers must have filled up the centre of the valley, and extending far away down beyond the terraces, formed the dam which banked up the drainage of the hills above the terraces, and thus formed a lake similar to the Merjelen-see in Switzerland. At the same time the main drainage of the great glacier passed along at a lower level, and issued from its ice cave miles lower down, as the stream of the great Aletsch does at the present day.

That the Tasman glacier has been down the present valley at almost its present level, past the foot of the slopes on which the terraces occur, is proved by the existence of several little mounds of old terminal moraine which the river has failed to remove; and until the structure of these terraces is more closely examined it is quite possible to suppose that they may have been formed by the direct action of the glacier banking up the *debris* that fell from the mountain sides.

The heat as we journeyed up the river bed was intense; dark masses of rain-clouds blocked up the Hooker valley, while the Tasman remained clear, except for a passing shower. Along the course of the river small whirlwinds followed each other at regular intervals, making themselves visible by the cloud of fine sand which they whirled upwards to a height of from 50 to 100 feet.

At three P. M., on February 12th, we commenced to ford the Tasman, and at 6·30 we reached its further shore. Halting for the

other possible invaders during our absence, we started for
On reaching a pack which I had sent on to the foot of t
we rearranged our loads, Kaufmann and Boss dividing all
carry into four loads, while my "swag" was quite as muc
manage over the rough ground. My men adopted the plan
each one load for an hour or so, and then, setting it down,
back again for the others, thus making the whole journey
this manner we arrived at the camping-ground we had
the shore of a little blue lake, where the whole drainage o
that forced its way beneath the boulders bubbled forth to
The lake was embosomed in dense scrub, which here cloth
moraine and the mountain sides. This scrub was compose
pines; birch, or more correctly beech (*Fagus*); veronicas, s
of which are indigenous to New Zealand, and shrubs of
coprosma, dracophyllum, &c., and as we came along w
resist eating the sweet red berries of *Podocarpus nivalis*, th
time we did not know what ill effects might ensue.
plants, the fine white *Ranunculus lyallii* was everywhere
it goes by the name of Mount Cook lily among the coloni
found its large succulent leaves most useful in our hats as
against the fierce rays of the mid-day sun. A little w
became common from this camp upwards, and ferns nestle
shade of every damp rock.

Keas, or Mount Cook parrots (*Nestor notabilis*), now
appearance, and came screaming close to the tent. Kaufm
couple, and soon had them picked, and in the soup-kettle,
added a brace of ducks to our larder. Parrot soup prov
that from this day forward we were never without some in
Since sheep were introduced into New Zealand these p
acquired a taste for kidney fat, and perching on the poor
animals, eat through their flesh, in order to obtain thi
Further up the glacier these birds were so tame, that
one on the head with a stick which I had in my hand. I
of about a dozen specimens of the kea which I examin
nothing but the green pips of the berries of *Podocarpus*
the birds seemed confined to the zone where these berries

As night closed in heavy drops of rain fell, and soon it be
a gale; but, ensconced in our felt sleeping-bags, we at firs
elements, and slept well. After midnight, however, the wea
so terrible that sleep was impossible. The tent could not have
away, as it was made on Mr. Whymper's plan, the sides and
all in one; but I felt sure it must soon split; it fluttered
and the torrents of rain never ceased lashing its sides. Thun
round the mountain peaks, and when morning came there was
ment. So far the tent resisted the rain, but now Kaufman
bag was getting wet from soaking the damp through the
then a pool formed in our opossum rug, and it was no lon
to keep dry. There was no chance of lighting a fire, so w

ivering till mid-day, and at three o'clock, seeing that it pro- or a similar night, and all our things were wet, we determined re the tent and provisions as best we could, and retreat to our camp. The wet scrub drenched us as we pushed our way ı it, but on reaching our camp we were soon into dry clothes. ather cleared for an hour or so about sunset, allowing us to supper in comfort; but as it began to blow and rain as night n, we made ourselves snug in our hammocks, and slept, in the banging of the tent walls and beating of the rain. Next s stormy, wet, and cold, the highest temperature being only After our mid-day meal we set off in our waterproofs to try ch the Hooker glacier; but finding we should have to mount ep slopes of the spur of Mount Cook through dripping ferns, we ished the attempt, and amused ourselves by running after and g some young wekas. The old birds came from all points to trate, and forming a wide circle, squealed and grunted forth ndignation, and as we returned their young ones unharmed, ere, I am sure, quite satisfied that their interference had a nportant influence over our actions. It cleared a little about showing the mountains glistening with fresh-fallen snow, and ttled in again for a bad night, the wind still blowing a gale ne north-west. At midnight we were aroused by the most torrents of rain; there seemed to be no wind with it, and in rning, when we awoke in bright sunshine, and looked out of t, we found the whole landscape, down almost to the foot of cier and surrounding hills, covered with a robe of freshly- snow. These lower hills are of course covered with snow in but it seldom lies on the flat valley for more than twenty-four t a time. We were much surprised at learning this from the rds, as for a long distance the valley may be considered to be ame level as the termination of the glacier, and land in such ity in Switzerland would be covered all through the winter any feet of snow. The wind was now from the south, the sky nd as the snow was rapidly melting, I determined to start by for the camp at the Blue Lake, spread out the things to dry, ve the men to follow when they had our lower camp dried and It rained a little again at night, but next day was fine to continue our journey, which we did as usual, my men over all the ground twice, and while they went back the ge I pitched the tent, and cut twigs for our bedding, coprosma onica scrub being still in abundance. I shall not go into all the of our troublesome journey; suffice it to say, that our fourth as pitched on the moraine abreast of the stakes I had erected glacier. On visiting them, however, I found them all lying te, and blown to some distance from the holes in which they ood. The sunshine and storms of the past seven days had ed the surface of the glacier, that we had some little difficulty ng the holes we had made. When we set the sticks up again,

and I ran my eye along them to the mountain side, I found that they were still in an almost perfect right line, showing that in that time no motion of any importance had taken place. This was, however, what might have been expected, owing to the flatness of the lower portion of the glacier, the incline being about 100 feet to the mile.

We returned to camp over piles of angular rocks alternating with gravel heaps, coming now and then upon a yawning chasm with sides of dirty ice and enclosing deep blue pools of ice water. The new moraine near the margin of the glacier overtopped a rampart of ancient moraine, showing that the glacier at a period not very remote was smaller than it is at present. Not only there, but at various other parts of our route, I made similar observations. The old moraine was consolidated by the disintegration of the rocks composing it, and afforded soil for numerous tufts of sword-grass and other smaller plants. Here for the first time we found the New Zealand Edelweis (*Gnaphalium grandiceps*), and my men seemed to take fresh heart after all their fagging work when we had our hat-bands adorned with the familiar little felt-like flowers. After a good night's rest on a bed of *Veronica hectori*, we continued our "swagging," and on the next afternoon, February 23rd, we reached our fifth and final camp.

We were now 3750 feet above the sea, having gained by a week's labour only 1450 feet of actual elevation, and Mount Cook still towered nearly 9000 feet above us. Our advance was here checked by the ice of the much-broken Ball glacier coming down from our left, and though we carried our "swags" on to its surface in hopes of camping farther up, the absence of scrub on the farther spurs of sufficient size to promise a supply of fire-wood made us retrace our steps and pitch our tent on a gravel flat, close to the mountain side in the angle formed by the Mount Cook and Tasman glaciers. Here a glacier stream provided us with water, and the vicinity of our camp was strewn with dead wood brought down by landslips and avalanches from the steep slopes above. While looking for a suitable nook for our tent, Boss came upon a little square patch of dwarf gnarled coprosma exactly the square of our tent: it grew by itself on the gravel in a snug corner, and seemed as if prepared so specially for our use that we did not wish to decline the hospitality of nature, so filling up the centre of the square with some cut bushes, we pitched our tent on it. Never was a bed more comfortable; its spring was perfect. We never sank to within less than five or six inches of the ground, and so long as the wekas contented themselves with squeaking and grunting, and not pecking upwards, we did not wish to deny them the comfortable lodging beneath us which they seemed to appreciate.

From this camp we made a long day's excursion up the main glacier, and completed our reconnaissance of the ridges of Mount Cook; and from a point on the medial moraine I took a circle of angles with a view to making my map, and secured a couple of negatives of the Hochstetter ice fall; but the light was so brilliant, there not being a cloud in the sky, that over exposure of my plates was

almost unavoidable. On this day we spent some time sounding crevasses. Into one moulin I lowered a stone with 320 feet of cord, but as the cord was found to have tangled, the observation could not be relied on. We then timed the fall of large stones, and on several occasions measured 5″ by my watch before the first crash was heard, giving a depth of 300 feet, and then as a series of bangs followed for as long again, these crevasses must at the lowest computation be 500 feet deep.

The glacier (Plate XVIII.) close to our camp, which I have named the Ball glacier, after John Ball, who may be looked upon as one of the fathers of Alpine exploration, had some points of special interest. Flowing from the S.W., it met the current of the main glacier coming from the north, and failing to stem it, was pushed aside down the valley, its lower portion thus making an acute angle with its former course. As our tent was in the angle, I had abundant opportunity for watching its great slopes of ice which stood up high above the moraine, and by observation I found the ice moved past at the rate of one foot per day. At one point the pressure had been sufficient to push down the moraine as a great wall might have been tumbled over, while immediately in front of our camp the glacier was building up the rampart by a constant dropping of angular stones. Even in the stillness of night these sounds evidence its icy life, and one night we heard a bang as of a cannon shot when some new crevasses sprang into existence.

The blocks of the moraine were all either sandstones or slates of the newer palæozoic formation, of which Mount Cook and all this range is composed, with occasional fragments of quartz, in which we kept a bright look out for gold and blocks of a kind of volcanic breccia, which, according to Professor V. Ball, who kindly examined a piece which I brought home, consists of fragments of pyroxene and felspar, the latter being much decomposed, and some free silica.

Our first attempt to scale Mount Cook by the southern arête was foiled by meeting a series of crags of the above-named slates, which owing to their rotten condition we could not climb. Our second attack ended in the face of a great sandstone cliff of the eastern spur. Our third and successful attempt was made for the greater part by snow and ice, and of the ascent I shall now give a few details. Immediately to the north of Mount Cook, Mount Tasman raises its glacier-clad peak, and from the basin between these two mountains descends, in a grand ice-fall, the Hochstetter glacier. This glacier forms one of the most splendid sights in the Southern Alps. Its chaos of *seracs* tinted with every icy hue, from beryl blue to silvery white, is of course quite inaccessible, as every moment the ice blocks topple over with loud boomings and crashes, and descend from level to level in clouds of ice dust. No speck of moraine pollutes its surface though a medial moraine appeared lower down, showing that the ice-fall is really a junction of two glaciers. To reach the basin or plateau above the Hochstetter ice-fall was now our object, so on the 1st of March we started at daybreak, with rugs for a bivouac and provisions for three days, and after crossing the Mount Cook glacier, and the Hochstetter glacier below

its ice-fall, we climbed the steep rocks of the spur from Mount Tas and after ten hours' work settled ourselves for the night on some s beneath a large boulder about 3000 feet above the Tasman glacie

Starting from our bivouac at six a. m., we reached the pl above the Hochstetter glacier, and then by a glacier coming between the northern arête and the arête connecting Mount with Mount Tasman, which I have called the Linda glacie gained the last steep ice slopes of the peak, and after abou hours' step-cutting stood on the highest ridge at 6·20 p.m. wind was N. W., the ice thawing rapidly; temperature about 40 my thermometer was broken I could not take the exact temper it may therefore have been even higher than 40°; it could not been much lower. My aneroid read 19·35 inches, which, with rection to bring it into comparison with the standard instrum the post office at Timaru, would be 19·05, and by comparison wit sea-level readings, furnished to me for that day by Dr. Hector, S intendent of the Meteorological department, New Zealand, our tion above the sea level would appear to have been between 1 and 12,500 feet, according as the possible corrections are adopted

The mountain has been measured trigonometrically from tw two stations by Mr. G. J. Roberts of the Westland Survey Depart and his result of 12,349 feet is no doubt the true elevation. Th a heavy gale was driving dark masses of rain-clouds in eddies the ice cornice on which we stood, we could see quite enou satisfy ourselves that we were on the ice cap of the highest We could not see the distant view; but there is no other pinna the mountain that can enter into competition with the pea climbed. A peak that seems almost as high, when looked at fro Tasman valley, only owes its chance of comparison to its being n the spectator. One peak alone with its little cap of ice presents as the *Höchste Spitze*, from any point of view from which a true mate of the mountain can be formed. In the hour of daylight remained we descended about 2000 feet; it then became quite and as heavy showers of rain and sleet beat upon us I called a Spending the nine hours of darkness standing on a ledge of roc resumed our descent next morning, reaching the Tasman glacier a and our camp at 7·30 p. m.

The vegetation in these high alpine regions was most interesting ronicas of various species were of the larger plants the most nume the *Veronica macrantha* with its large white flowers was especially b tiful, and quite takes the place of the little rhododendron of Swi land. Above the mean snow line, which is about 3000 feet l than a similar line in the European Alps, numerous alpine plants a few dwarfed stragglers from lower regions, flourished in sui situations. Of these alpine plants I made a collection, noting highest point at which I observed them growing. Mr. Armstron the Botanical Gardens, Christchurch, kindly named most of these me; the few he was doubtful about I have since shown to Sir Jo

Iooker, and one of these being a new species of the genus *Haastia*, e has paid me the compliment of calling by my name. Speaking of , he says: "This last is a beautiful thing, of which I hope that owers may be found by future climbers." It grew in white velvet-ke bosses on the rocks facing the north, the barometer being at 3·90 when I gathered it on the southern spur, giving an elevation n that day of 6500 feet. Above this there was no sign of vegetation, xcept a little lichen, which extended to the very top stone of Iount Cook. What struck me most about all this vegetation was that, ith the exception of a yellow ranunculus and a little violet tinge in he flowers of veronica, all the flowers were white. The pink of the rimula and the blue of the gentian, so familiar to my eyes, were ltogether absent. My companions and I had worked so harmoniously ogether, that we did not break up our alpine camp without many angs of regret, that our days among the glorious scenery of the outhern Alps had come to a close. Once more we had to return to he haunts of men, and I cannot conclude this Paper without ex-ressing our appreciation of the boundless hospitality with which we ere everywhere received by the hospitable people of New Zealand.

ome Alpine Plants of New Zealand, Mount Cook District, collected in February and March, 1882.

NAME OF PLANT, AND AUTHORITY.	Elevation, in feet, of Station.
Ranunculus sericophyllus (Armstrong), ...	6400
Ligusticum aromaticum (Hooker, fil.), . . .	6400
Hectorella cæspitosa (Hooker, fil.), ...	6400
Raoulia grandiflora (Hooker, fil. and Armstrong), .	6400
Haastia greenii (Hooker, fil.), ...	6500
Gnaphalium grandiceps (Armstrong), . . .	3–5000
Gnaphalium bellidioides (Armstrong), . . .	3–4000
Helophyllum colensoi (Hooker, fil.), . . .	—
Dracophyllum rosmarinifolium (dwarf) (Armstrong),	—
Coprosma pumila (dwarf) (Armstrong), . . .	6400
Euphrasia (?)	—
Aelmersia sessiflora, ...	6400

Some Meteorological Observations taken by W. S. Green *in New Zealand Alps, with Barometer reading at Sea-level worked out by* Dr. Hector, F.R.S., *at 32° Fahrenheit, and at 9 A.M.*

N.B.—The barometrical readings were made with an aneroid by Negreti and Zambra, having a range of from 15 to 31 inches, and which, by comparison with the standard instrument in the Post Office, Timaru (the nearest to Mount Cook), read ·3 too high. The comparison was made on February 10th.

Date.	Hour.	Place.	Weather.	Wind.	Barometer.	Shade Thermometer, F.	Bar. at Sea-level.	Observations.
Feb. 11	11 A.M.	Albury, . . .	Threatening, . .	S.	29·1	—	29·1	
„ 11	1 P.M.	Silver streams, . .	Overcast, . .	—	28·6	—	—	
„ 11	7 P.M.	Tekapo, . . .	Clear, . . .	—	27·2	52°	—	
„ 12	6 A.M.	do. . . .	do., . . .	calm	27·6	–	29·94	
„ 13	6 A.M.	Birch Hill, . . .	Clear after rain, .	N.	28·0		30·05	
„ 14	10 A.M.	1st camp, foot of Tasman Glacier, . .	Clear, . . .	N.W.	27·70	82	30·08	
„ 14	6 P.M.	do., do.,	Fine, with clouds, .	W.	27·65	64	—	
„ 15	—	do., do.,	— —	—	—	—	29·98	
„ 16	—	do., do.,	— —	—	—	—	30·06	
„ 17	6 A.M.	do., do.,	Cloudy, . .	W.	27·40	43	29·40	
„ 18	[illegible]	[illegible]	Wind and rain, .	N.W.	[illegible]	44	29·25	

		4 P.M.	2nd camp,	do.,	[illegible]	[illegible]	[illegible]	[illegible]	
,,	21	5 P.M.	3rd camp,	Threatening,	S.E.	26·75	—	29·70	Thermometer broken.
,,	22	6 A.M.	do.,	Clear,	W.	27·0	—	30·12	
,,	23	6 A.M.	4th camp,	do.,	W.	26·80	—	30·20	
,,	23	6 P.M.	5th camp,	Clouds, fine,	W.	26·57	—	—	
,,	24	6 A.M.	do.,	Clouds and rain,	N.W.	26·56	—	30·30	
,,	24	6 P.M.	do.,	Clear,	W.	26·56	—	—	
,,	25	6 A.M.	do.,	do.,	S.W.	26·50	—	30·22	Ascended this day to 7000 ft. from the south arête; air still, sky blue; not a cloud visible.
,,	25	8 P.M.	do.,	do.,					
,,	26	6 A.M.	do.,	do.,					Temperature during day about 80° in shade, seldom falling to 32° at night.
,,	26	6 P.M.	do.,	do.,					
,,	27	6 A.M.	do.,	do.,					Ascended to 8000 ft. on eastern spur: some light clouds; clear moonlight.
,,	28	6 A.M.	do.,	Overcast,	—	—	—	·18	
Mar.	1	6 P.M.	Bivouac on Tasman spur	Fine,	S.E.	23·0	—	30·18	
,,	2	6·20 P.M.	Summit, Mt. Cook,	Clouds, rain, high wind	N.W.	19·35	about 40	30·11	Rapid thaw; ice streaming with water; temperature at sea-level 65°.
,,	3	7 P.M.	5th camp,	Thunder, rain,	N.	26·10	—	30·98	
,,	4	6 A.M.	do.,	Clouds, fine, showers,	N.W.	26·10	—	29·97	

Plate XVIII.


HECTOR GLACIER
MOUNT TASMAN
MOUNT HAIDINGER
FRANCIS JOSEPH GLACIER
GLACIER
MOUNT DE LA BECHE
MOUNT BEAUMONT
CLASSEN GLACIER
MOUNT

,,	[illegible]	[illegible]	[illegible]			[illegible]	—	29·70	Thermometer broken.
,,	22	6 A.M.	do.,	Clear,	W.	27·0	—	30·12	
,,	23	6 A.M.	4th camp,	do.,	W.	26·80	—	30·20	
,,	23	6 P.M.	5th camp,	Clouds, fine,	W.	26·57	—	—	
,,	24	6 A.M.	do.,	Clouds and rain,	N.W.	26·56	—	30·30	
,,	24	6 P.M.	do.,	Clear,	W.	26·56	—	—	
,,	25	6 A.M.	do.,	do.,	S.W.	26·50	—	30·22	Ascended this day to 7000 ft. from the south arête; air still, sky blue; not a cloud visible.
,,	25	8 P.M.	do.,	do.,	calm	26·50	—	—	
,,	26	6 A.M.	do.,	do.,					Temperature during day about 80° in shade, seldom falling to 32° at night.
,,	26	6 P.M.	do.,	do.,					
,,	27	6 A.M.	do.,	do.,					Ascended to 8000 ft. on eastern spur: some light clouds; clear moonlight.
,,	28	6 A.M.	do.,	Overcast,					
Mar.	1	6 P.M.	Bivouac on Tasman spur	Fine,					
,,	2	6·20 P.M.	Summit, Mt. Cook,	Clouds, rain, high wind	N.W.	19·35	about 40	30·11	Rapid thaw; ice streaming with water; temperature at sea-level 65°.
,,	3	7 P.M.	5th camp,	Thunder, rain,	N.	26·10	—	30·98	
,,	4	6 A.M.	do.,	Clouds, fine, showers,	N.W.	26·10	—	29·97	

LXXXVIII.—COMPUTATION OF TIDES—RESULTS OF THEORY AND OBSERVATION. By JAMES PEARSON, M.A., Ex-Scholar (15th Wrangler) of Trinity College, Cambridge; Vicar of Fleetwood. (With Plate XIX.)

[Read, November 13, 1882.]

THE subject of Tides, upon which, from time to time, I have had the honour of addressing the Royal Irish Academy, is one of which the importance can hardly be overrated, whether we regard it in its connexion with physical science or in its reference to practical navigation. A ship, on arriving at her port of destination, requires a safe access and convenient place of discharge, and these cannot be secured unless it is ascertained that a sufficient depth of water will be found to keep her afloat, and that a suitable time has been fixed upon for her entrance into the tidal harbour. Hence the exigencies of the case demand strict attention be paid to the amount of rise and fall of tide. A rough guess is not sufficient; an error of a few inches may cause the vessel to take the ground, and so to be left high and dry twice in twenty-four hours; and this for several days, in fact until the return of spring tides supplies water enough for her draught. Now this has a double inconvenience and loss. There is the expense of delay in her discharge, which is often very considerable—wages incurred without work, and time idly squandered. If an attempt is made to lighten her by removing some of her cargo, it may be unsuccessful, and involves expenditure. More than this, the grounding of a ship of magnitude and in full load is most injurious. A severe strain takes place from the effects of which she can hardly ever be recovered; and if the ground be very hard and uneven, she may "break her back." Now these are not exaggerated dangers; and therefore whatever can be done to prevent their occurrence is a real boon to mercantile interests.

Impressed with these considerations, and having all the theoretical information on the subject which a knowledge of mathematics could supply, combined with an ardent love of what I may call an "unfrequented study," with the singular advantage of having my home within two hundred yards of a self-registering tide-guage, I have for the last twelve years practically applied myself, not only to the main problem, but also to the discrepancies involved in consequence of atmospheric disturbances, and evidence is now forthcoming to show that the success has been very remarkable. Self-praise is no recommendation, but those who have used the Admiralty Tide Tables for Liverpool during the last five years, have been prompt to testify to the improvement which has taken place in their predictions of the height of tides. The calculations now are based on a modification of Bernouilli's, or the Equilibrium Theory; and the figures employed were, in the first instance, taken from Sir John W. Lubbock's "Elementary Treatise on

the Tides." But the principle of the method is one which never occurred to either of these philosophers, nor, if known at all, has it been published by anyone else. The principle involved is this: that the configuration of land and water on the surface of the globe brings it to pass that the *direction* of the moon's motion in respect to the equator makes a very great difference in the magnitude of the tide-wave which reaches our shores. For when the moon advances from south to north declination, crossing the equator, as she sometimes does, at an angle of 28 degrees, it is seen that her line of motion approximately coincides with the general trend of the Atlantic Ocean, at the time when the earth's rotation brings that part of the globe directly beneath her, and this causes a further development of the tide-wave in the direction of Europe and North America; whereas, when the moon declines from north declination to south, her course is diagonal to the former one, crossing the Atlantic, roughly speaking, in the direction of its *breadth*, whilst in the other case she crossed in the direction of its *length*. The like phenomena take place in connexion with the obverse action of the moon on the opposite side of the globe, when that is the agency considered. The same remarks also apply in regard to the action of the sun, only this action is much more gradual and constant. Following out the principles thus briefly enumerated, a patient attention to the actual phenomena for twelve years has enabled me to draw up tables of computation which include every possible cause which can effect or interfere with the working of the tides.

Other principles of computation, however, have found favour with the Tidal Committee of the British Association, for the details of which the Annual Reports must be consulted. In the "Harmonic Analysis of the Tides," as it is called, the various changes of level to which the sea is subject, moment by moment, in consequence of the tide-generating forces, are ascertained by the enumeration of a series of Harmonic Functions, each of which involves the time for which the computation is made, certain quantities depending on the angular velocity of the earth's rotation, the rates of relative orbital motion of the moon and sun, and certain constants. The relative merits of these rival theories (for such they are, though to a certain extent based on common fundamental physical laws) can only be tested by comparison with observation, and for this purpose no place is more eligible than Liverpool, where the equinoctial tides sometimes range as far as thirty-one feet from low-water. I am not aware, however, that this has been done.

Meantime, I desire to send to the Academy a sort of challenge-list of comparisons, taken for a semi-lunation in the month of June, 1882. The atmospheric conditions during this period were exceedingly constant, and so they very slightly affect the results. I am now engaged in forming a Table, the arguments of which are the direction and force of the wind on the one hand, and the height of the barometer on the other. By the aid of this, predictions may be made with much accuracy in unsettled weather.

Comparison of Tides from June 17 to June 29, 1882, at Fleetwood, confirmed by Registers at Liverpool.

Date.	Calculation.	Observation.	Error.	Barometer.	Wind, &c.
1882.	ft. in.	ft. in.	in.	in.	
June 17.	26 0	25 7	− 5	29·9.	W.S.W., slight.
,, 18.	26 4	26 5	+ 1	29·6.	W., fresh.
	25 7	25 6	− 1	,,	N.N.W., ,,
,, 19.	25 9	25 10	+ 1	29·8.	,, ,,
	24 11	24 10	− 1	29·9.	,, ,,
,, 20.	25 3	25 2	− 1	,,	,, calm.
	23 10	23 11	+ 1	,,	,,
,, 21.	24 2	24 4	+ 2	29·8.	W.S.W., slight.
	22 10	23 2	+ 4	,,	,, ,,
,, 22.	23 3	23 4	+ 1	29·7.	,, ,,
	22 1	22 4	+ 3	,,	N., calm.
,, 23.	22 5	22 5	0	,,	W.S.W., ,,
	21 1	21 5	+ 4	,,	calm.
,, 24.	21 4	21 5	+ 1	29·9.	,,
	20 4	20 9	+ 5	29·8.	S., fresh, bar. falling
,, 25.	20 7	20 11	+ 4	29·9.	,, ,,
	20 1	20 4	+ 3	30·0.	,, ,,
,, 26.	20 6	20 8	+ 2	,,	calm.
	20 10	20 10	0	,,	,,
,, 27.	21 3	21 2	− 1	30·1.	N.N.W., slight.
	21 11	22 0	+ 1	,,	,, ,,
,, 28.	22 3	22 3	0	30·2.	S.W., calm.
	23 3	23 4	+ 1	,,	N., ,,
,, 29.	23 6	23 4	− 2	,,	bar. rising. ,,
	24 10	24 8	− 2	,,	,, ,,

But, in order to submit the newly-devised method to a still m severe and crucial test, it is necessary to examine what may be cal *correlative tides*, i.e. tides having nearly the same constituents: fo like causes produce like effects in nature, such tides should show same agreement between theory and observation. This plan beco more simple, because any one tide in any year has only one tide co sponding to it in any other year; and if there be a discordance, it r be due to a difference in atmospheric conditions, and will indicate change of height of tide arising from this cause.

Thus, if we take the Lunar and Solar Tide which is connected with that transit of the moon, which occurs in *May*, at between 6h. and 7h., Greenwich apparent time, and compare theory with observation during the last seven years, we find as follows :—

Years.	Moon's Trans.	Moon's Par.	Moon's Dec. S. asc.	Calculation.	Observation.	Error.
	h. m.	′ ″	° ′	ft. in.	ft. in.	in.
1876.	6 31	55·27	14·17	20 9	20 3	− 6
1877.	6 33	54·16	16·53	20 2	20 2	0
1878.	6 41	54·18	5·27	21 1	21 0	− 1
1879.	6 45	55·38	8·45	21 5	21 2	− 3
1880.	6 25	58· 4	13·44	22 2	22 2	0
1881.	6 17	58·52	6·14	23 3	23 2	− 1
1882.	6 25	59·16	8·52	23 0	23 0	0

The above are favourable specimens: all others are not equally so. We shall next examine the atmospheric conditions which seem to account for the variation. Thus, if we take the Lunar and Solar Tides of *August*, which are incident to the moon's transit between 11h. and noon in the same years, with the atmospheric conditions—

Years.	Moon's Trans.	Moon's Par.	Moon's Dec. N. desc.	Calculation.	Observation.	Barometer.	Wind, &c.
1876.	11·26	60·30	17·44	28· 0	27·9	29·8.	calm.
1877.	11·50	61·19	18·27	28· 3	28·2	29·8.	N.W., slight.
1878.	11·44	60·44	9·41	28· 9	28·7	29·7.	S., slight.
1879.	11·14	57·36	15·27	26· 6	26·5	29·6.	N.W., fresh.
1880.	11·49	55· 6	14·17	25·10	25·9	29·8.	W., slight.
1881.	11·16	54· 4	10· 8	25· 5	25·8	29·3.	S., strong.

So long as the atmospheric conditions are not very diverse, it is found that the agreement between theory and observation is very nearly perfect; the changes in the moon's parallax and declination, each producing their own separate effects with undeviating regularity, but when the atmospheric conditions change the effects become apparent. Thus, for the March Tides, lunar and anti-solar, transits between 4h. and 5h., P.M.

Years.	Moon's Trans.	Moon's Par.	Moon's Dec. S. desc.	Calculation.	Observation.	Barometer.	Wind, &c.
1877.	4·46	56· 2	25·34	20·10	20·7	29·5.	N.
1878.	4·12	58· 1	26·37	22· 5	22·3	29·8.	N.
1879.	4·31	59·19	25·15	22· 7	23·1	29·7.	S.W.
1880.	4·35	59·17	22·55	22· 8	23·9	29·7.	W.N.W., strong.
1881.	4·39	58·40	23· 6	22· 0	22·4	29·7.	S.W., fresh.
1882.	4·52	56·53	21· 3	21· 1	21·3	30·5.	W.S.W., fresh.

The last tide would have had its height augmented by th
and force of the wind, but this was counteracted by the hig
tric pressure.

In conclusion, enough has been said to show the progre
accurate calculation, and the data upon which the effects
pheric conditions may be estimated. A similar method may
in the case of any other ports to which attention may be dire
instance, in the case of Kurrachee, it is found that the diurn
lity is very visible, when the moon or anti-moon is south of th
at the instant of the transit, which occurs twelve hours p
The configuration of land and water affects the course of
as certainly in the Indian as in the Atlantic Ocean; everywh
duces irregularities which cannot be ignored, when special
have to be calculated.

Plate XIX. represents the curves formed by the tides, as
by W. Parkes, E.C., at Kurrachee, and referred to in the Re
British Association for 1870. It shows, by means of the gr
cess at the foot of the diagram, the law of the "diurnal in
for that place. For an explanation of this process see thes
ings, antea, page 73. The law is this: when the moon is
equator, the lunar tides (combined with the solar) are hi
arrive at Kurrachee about twelve hours after the transit
the anti-moon is below the equator, the anti-lunar tides
with the anti-solar) are highest. The diurnal and semi-diu
are also shown.

XIX.—CONTRIBUTIONS TO THE THEORY OF SCREWS. By ROBERT S. LL, LL.D., F.R.S., Andrews Professor of Astronomy in the iversity of Dublin, and Royal Astronomer of Ireland.

[Read, November 13, 1882.]

heory of "emanants" in modern algebra (Salmon's *Higher a*, 3rd ed., p. 108) is specially appropriate for throwing light ew co-ordinate transformations. The present Paper relates to ıbject.

t $a_1, \ldots a_6$ denote the six co-ordinates of a twist or of a wrench. regard the amplitude of the twist or the intensity of the wrench ty, then the six co-ordinates become the co-ordinates of the For our present purpose we require the six co-ordinates to be ndent variables, and therefore we shall regard them as the co-tes of the Dyname itself, not merely of the screw on which it s. To specify the screw five constants are required; one con-nore gives the intensity of the Dyname, making six in all. The ne can thus be completely expressed by the six co-ordinates, of each one is absolutely independent of the rest.

t α' be the intensity of the Dyname on α; then α' is proportional $\ldots a_6$ insomuch, that if the Dyname be replaced by another on me screw α, but of intensity $x\alpha'$, the co-ordinates of this new ne will be $xa_1, \ldots xa_6$.

t β be a second Dyname on another screw quite arbitrary as to sition and as to its intensity β'. Let the co-ordinates of β, re-to the same screws of reference, be $\beta_1, \ldots \beta_6$. If we suppose ame of intensity $y\beta'$ on the screw β, then its co-ordinates will $, \ldots y\beta_6$. Let us now compound together the two Dynames of ities $x\alpha'$ and $y\beta'$ on the screws α and β. They will, according laws for the composition of twists and wrenches (*Theory of* , p. 11), form a single Dyname on a third screw lying on the cylindroid as α and β. The position of the resultant screw is hat it divides the angle between α and β into parts whose sines he ratio of y to x. The intensity of the resulting Dyname is also ined (as in the parallelogram of force) to be the diagonal where y are the sides, and the angle between them is the angle between β. It is important to notice that in the determination of this nt the screws of reference bear no part; the position of the re-t Dyname on the cylindroid as well as its intensity each depend upon the two original Dynames, and on the numerical magni-r and y.

e have now to form the co-ordinates of the resulting Dyname, or nponents when decomposed along the six screws of reference. rst Dyname has a component of intensity xa_1 on the front screw; the second Dyname has a component $y\beta_1$, it follows that the

sum of these two must be the component of the resultant. Thus have for the co-ordinates of the resultant Dyname the expressions

$$x\alpha_1 + y\beta_1, \ldots x\alpha_6 + y\beta_6.$$

Let us suppose that without in any particular altering either of Dynames α and β we make a complete change of the six screws of ference. Let the co-ordinates of α with regard to these new sc be $\lambda_1, \ldots \lambda_6$, and those of β be $\mu_1 \ldots \mu_6$. Precisely the same a ment as has just been used will show that the composition of Dynames $x\alpha'$ and $y\beta'$ will produce a Dyname whose co-ordinates $x\lambda_1 + y\mu_1, \ldots x\lambda_6 + y\mu_6$. We thus see that the Dyname defined by co-ordinates $x\alpha_1 + y\beta_1, \ldots x\alpha_6 + y\beta_6$, referred to the first group of ference screws is absolutely the same Dyname as that defined by co-ordinates $x\lambda_1 + y\mu_1, \ldots x\lambda_6 + y\mu_6$ referred to the second grou reference screws, and that this must remain true for every valu x and y.

In general, let $\theta_1, \ldots \theta_6$ denote the co-ordinates of a Dyname in first system, and $\phi_1, \ldots \phi_6$ denote those of the same Dyname in second system. Let $f(\theta_1, \ldots \theta_6)$ denote any homogeneous functio the first Dyname, and let $F(\phi_1, \ldots \phi_6)$ be the same function tr formed to the other screws of reference. Then we have

$$f(\theta_1, \ldots \theta_6) = F(\phi_1, \ldots \phi_6)$$

as an identical equation which must be satisfied whenever the Dyna defined by $\theta_1, \ldots \theta_6$ is the same as that defined by $\phi_1, \ldots \phi_6$. We m therefore have

$$f(x\alpha_1 + y\beta_1, \ldots x\alpha_6 + y\beta_6) = F(x\lambda_1 + y\mu_1, \ldots x\lambda_6 + y\mu_6).$$

These expressions being homogeneous, they may each be develop in ascending powers of $\frac{y}{x}$. But as the identity must subsist for ev value of this ratio, we must have the coefficients of the various pow equal on both sides. The expression of this identity gives us a ser of equations which are all included in the form—

$$\left(\beta_1 \frac{d}{d\alpha_1} + \ldots + \beta_6 \frac{d}{d\alpha_6}\right)^n f = \left(\mu_1 \frac{d}{d\lambda_1} + \ldots + \mu_6 \frac{d}{d\lambda_6}\right)^n F.$$

The functions thus arising are well known as "emanants" in theory of modern algebra, and we have now proved that they are variants of the original quantic. It is instructive to notice how in mately this branch of algebra is connected with the Dynamical c ceptions in the theory of screws. The cases which we shall consi are those of $n = 1$ and $n = 2$. In the former case the emanant may written

$$\beta_1 \frac{df}{d\alpha_1} + \ldots + \beta_6 \frac{df}{d\alpha_6}.$$

It will of course be understood that f is perfectly arbitrary, but results of any interest are only to be anticipated when f has been chosen with special relevancy to the Dyname itself, as distinguished from the influence due merely to the screws of reference. We shall first take for f the square of the intensity of the Dyname, the expression for which is found in the *Theory of Screws*, p. 34, to be

$$R = a_1^2 + \ldots + a_6^2 + 2a_1a_2(12) + \ldots,$$

where (12) denotes the cosine of the angle between the first and second screws of reference, which are here taken to be perfectly arbitrary. The second group of reference screws we shall take in a special form. They are to be located two by two on three intersecting rectangular axes (*Screws*, pp. 46, 172): so that

$$R = (\lambda_1 + \lambda_2)^2 + (\lambda_3 + \lambda_4)^2 + (\lambda_5 + \lambda_6)^2.$$

Introducing these values, we have, as the first emanant,

$$\Sigma a_1\beta_1 + \Sigma(a_1\beta_2 + a_2\beta_1)(12) = (\mu_1 + \mu_2)(\lambda_1 + \lambda_2) + (\mu_3 + \mu_4)(\lambda_3 + \lambda_4) + (\mu_5 + \mu_6)(\lambda_5 + \lambda_6);$$

but in the latter form the expression obviously denotes the cosine of the angle between a and β where the intensities are both unity; hence, *whatever be the screws of reference*, we must have for the cosine of the angle between the two screws the result

$$\Sigma a_1\beta_1 + \Sigma(a_1\beta_2 + a_2\beta_1)(12),$$

an expression otherwise arrived at in *Trans.*, R. I. A., vol. xxv., Science, p. 306.

In general we have the following formula for the cosine of the angle between two Dynames multiplied into the product of their intensities:—

$$\tfrac{1}{2}\theta_1\frac{dR}{da_1} \quad . \quad . \quad . \quad + \tfrac{1}{2}\theta_6\frac{dR}{da_6}.$$

This expression, equated to zero, gives the condition that the two Dynames be rectangular.

If three screws, a, β, γ, be all parallel to the same plane, and if θ be a screw normal to that plane, then we must have

$$\theta_1\frac{dR}{da_1} \quad . \quad . \quad . \quad + \theta_6\frac{dR}{da_6} = 0,$$

$$\theta_1\frac{dR}{d\beta_1} \quad . \quad . \quad . \quad + \theta_6\frac{dR}{d\beta_6} = 0,$$

$$\theta_1\frac{dR}{d\gamma_1} \quad . \quad . \quad . \quad + \theta_6\frac{dR}{d\gamma_6} = 0.$$

Since a screw of a three-system can be drawn parallel to any
tion, it will be possible to make any three of the quantities θ_1
equal to zero. Hence, we have as the condition that the three
α, β, γ, shall be all parallel to a plane the evanescence of all
terminants of the type

$$\begin{vmatrix} \frac{dR}{d\alpha_1}, & \frac{dR}{d\alpha_2}, & \frac{dR}{d\alpha_3} \\ \frac{dR}{d\beta_1}, & \frac{dR}{d\beta_2} & \frac{dR}{d\beta_3} \\ \frac{dR}{d\gamma_1}, & \frac{dR}{d\gamma_2} & \frac{dR}{d\gamma_3} \end{vmatrix}.$$

If the three screws, α, β, γ, be co-cylindrical, these condition
of course be fulfilled; but in this case the required condition
expressed more simply, for we must have equations of the type

$$\gamma_1 = \lambda\alpha_1 + \mu\beta_1,$$

$$\cdot \quad \cdot \quad \cdot \quad \cdot$$

$$\gamma_6 = \lambda\alpha_6 + \mu\beta_6,$$

so that, if the three screws be co-cylindroidal, every determi
the type

$$\begin{vmatrix} \alpha_1, & \beta_1, & \gamma_1 \\ \alpha_2, & \beta_2, & \gamma_2 \\ \alpha_3, & \beta_3, & \gamma_3 \end{vmatrix}$$

must be equal to zero.

The locus of the screws θ perpendicular to α is represented
equation

$$\theta_1 \frac{dR}{d\alpha_1} \quad . \quad . \quad . \quad + \theta_6 \frac{dR}{d\alpha_6} = 0.$$

If we assume that the screws of reference are coreciprocal
the equation just written can only denote all the screws recipr
the one screw whose co-ordinates are

$$\frac{1}{p_1}\frac{dR}{d\alpha_1}, \quad . \quad . \quad . \quad \frac{1}{p_6}\frac{dR}{d\alpha_6}.$$

It is manifest that all the screws perpendicular to a giv
cannot be reciprocal to a single screw unless the pitch of that sc
infinite, otherwise the condition

$$(p_\alpha + p_\theta) \cos\phi - d \sin\phi = 0$$

ıld not be fulfilled. We therefore see that the co-ordinates just itten can only denote those of a screw of infinite pitch parallel to α.

If x be a variable parameter, then the co-ordinates

$$\alpha_1 + \frac{x}{p_1} \cdot \frac{dR}{d\alpha_1}, \quad . \quad . \quad . \quad \alpha_6 + \frac{x}{p_6} \cdot \frac{dR}{d\alpha_6}$$

st denote a screw of variable pitch x on the same screw as α. We thus conducted by a more direct process to the results previously ained (*Screws*, p. 100).

We may also consider that function of the co-ordinates of a Dyname ch, being always proportional to the pitch, becomes exactly equal he pitch when the intensity is equal to unity. More generally, may define the function to be equal to the pitch multiplied into the are of the intensity, and it is easy to assign a physical meaning to function. It is half the work done in a twist against a wrench, he same screw, where the amplitude of the twist is equal to the nsity of the wrench. Referred to *any* co-ordinates, we denote this tion by V expressed in terms of $\lambda_1 \ldots \lambda_6$. If we express the same tion by reference to six coreciprocal axes with co-ordinates $\alpha_1 \ldots \alpha_6$, have the result

$$p_1\alpha_1^2 + \quad . \quad . \quad . \quad p_6\alpha_6^2 = V.$$

Forming now the first emanant, we have

$$2p_1\alpha_1\beta_1 + \quad . \quad . \quad . + 2p_6\alpha_6\beta_6 = \mu_1 \frac{dV}{d\lambda_1} \quad . \quad . \quad . + \mu_6 \frac{dV}{d\lambda_6};$$

the expression on the left-hand side denotes the product of the two nsities into the vertical coefficient of the two screws; hence the ht-hand member must denote the same. If, therefore, *after the differentiations* we make the intensities equal to unity, we thus have the owing expression for the virtual coefficient between two screws λ l μ referred to *any* screws of reference whatever:—

$$\mu_1 \frac{dV}{d\lambda_1} \quad . \quad . \quad . \quad + \mu_6 \frac{dV}{d\lambda_6} = 0.$$

Suppose, for instance, that λ is reciprocal to the first screw of refe-ce, we have

$$\frac{dV}{d\lambda_1} = 0.$$

This can be verified in a somewhat instructive manner. We have

$$V = p\lambda'^2,$$

$$\frac{dV}{d\lambda_1} = \lambda'^2 \cdot \frac{dp}{d\lambda_1} + 2\lambda' p \frac{d\lambda'}{d\lambda_1};$$

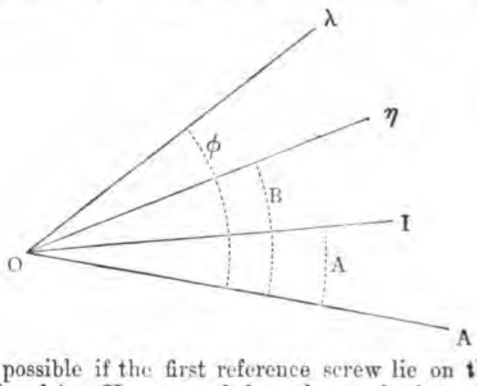
and, therefore, if λ be reciprocal to the first screw of ref
formula to be proved is

$$\lambda'^2 \frac{dp}{d\lambda_1} + 2\lambda' p \frac{d\lambda}{d\lambda_1} = 0.$$

A few words will be necessary on the geometrical sign
the differentiation involved. Suppose a Dyname λ to be
six co-ordinate screws of absolute generality, and let us s
one of these co-ordinates, for instance λ_1, be permitted t
corresponding situation of λ_1 also changes, and considering
the co-ordinates in succession, we thus have six routes establ
which λ will travel in correspondence with the growth of
priate co-ordinate. Each route is, of course, a ruled surfa
conception of a mere surface is not adequate to express the
must also associate a linear magnitude with each generator
face, which is to denote the pitch of the corresponding scre
λ and another screw on one of the routes, we can draw a
through these two screws. It will now be proved that thi
is itself the locus in which α moves, when the co-ordinate
thereto changes its value. Let θ be the screw arising from
in the co-ordinate λ_1; a wrench on θ of intensity θ'' has con
intensities $\theta''_1, \ldots \theta''_6$. A wrench on λ has components λ
But from the nature of the case,

$$\frac{\theta''_2}{\lambda''_2} = \frac{\theta''_3}{\lambda''_3} \quad . \quad . \quad . \quad . \quad = \frac{\theta''_6}{\lambda''_6}.$$

If therefore θ'' be suitably chosen, we can make each of
-1, so that when θ'' and λ'' are each resolved along the si
reference, all the components except $\theta''_1 - \lambda''_1$ shall neutralize



can only be possible if the first reference screw lie on the
containing θ and λ. Hence we deduce the result that each
cylindroids must pass through the corresponding screw of
and thus we have a complete identification view of the rout

by a screw in correspondence with the variation of one of its co-ordinates.

Let the six screws of reference be 1, 2, 3, 4, 5, 6. Form the cylindroid $(\lambda, 1)$, and find that one screw η on this cylindroid which has with 2, 3, 4, 5, 6, a common reciprocal. Let the adjoining figure be a pencil of four rays parallel to four screws on the cylindroid. Let OA be parallel to one of the principal screws; $O\lambda$ be parallel to λ, $O\eta$ to η, and $O\iota$ to the first screw of reference. Let the angle $AO\iota$ be denoted by A, the angle $AO\eta$ by B, and the angle $AO\lambda$ by ϕ. To find the component λ_1 we must decompose λ', a twist on λ, into two components, one on η, the other on 1. The component on η can be completely resolved along the other five screws of reference, since the six form one system with a common reciprocal. If we denote by η' the component on η, we then have

$$\frac{\lambda'}{\sin(B-A)} = \frac{\lambda_1}{\sin(\phi - B)} = \frac{\eta'}{\sin(\phi - A)};$$

and if a and b be the pitches of the two principal screws on the cylindroid, we have for the pitch of λ the equation

$$p = a\cos^2\theta + b\sin^2\theta;$$

also $\dfrac{dp}{d\lambda_1} = \dfrac{dp}{d\phi}\cdot\dfrac{d\phi}{d\lambda_1}$, because the effect of a change in λ_1 is to move the screw along this cylindroid.

Now $$\lambda_1 = \eta'\frac{\sin(\phi - B)}{\sin(\phi - A)},$$

and as the other co-ordinates are to be left unchanged, it is necessary that η' be constant, so that

$$\frac{d\lambda_1}{d\phi} = \eta'\frac{\sin(B-A)}{\sin^2(\phi - A)},$$

and hence $$\frac{dp}{d\lambda_1} = (b-a)\sin 2\phi\,\frac{\sin^2(\phi - A)}{\eta'\sin(B-A)}.$$

Also $$\frac{d\lambda'}{d\lambda_1} = \frac{d\lambda'}{d\phi}\cdot\frac{d\phi}{d\lambda_1} = -\cos(\theta - A).$$

Hence, substituting in the equation

$$\lambda'\frac{dp}{d\lambda'} + 2p\frac{d\lambda'}{d\lambda_1} = 0,$$

we deduce $$a = b\tan\phi\tan A;$$

but this is the condition that λ and the first screw of reference shall be reciprocal (*Screws*, p. 37).

The emanants of the second degree are represented by the equa

$$\left(\beta_1 \frac{d}{da_1} + \ldots + \beta_6 \frac{d}{da_6}\right)^2 f = \left(\mu_1 \frac{d}{d\lambda_1} + \ldots + \mu_6 \frac{d}{d\lambda_6}\right)^2 F,$$

when F is the function into which f becomes transformed when co-ordinates are changed from one set of screws of reference to anot If we take for f either of the functions already considered, these e tions reduce to an identity; but retaining f in its general form, we deduce some results of very considerable interest. The discus which now follows was suggested by the very ingenious reaso employed by Professor Burnside in the theory of orthogonal trans mations (see Williamson's *Differential Calculus*, p. 412).

Let us suppose that we transform the function f from one set of reciprocal screws of reference to another system. Let $p_1 \ldots p_6$ be pitches of the first set, and $q_1, \ldots q_6$ be those of the second set. T we must have

$$p_1\beta_1^2 + \ldots + p_6\beta_6^2 = q_1\mu_1^2 + \ldots + q_6\mu_6^2,$$

for each merely denotes the pitch of the Dyname multiplied into t square of its intensity. Multiply this equation by any arbitrary fact x and add it to the preceding, and we have

$$\left(\beta_1 \frac{d}{da_1} + \ldots + \beta_6 \frac{d}{da_6}\right)^2 f + x(p_1\beta_1^2 + \ldots + p_6\beta_6^2)$$

$$= \left(\mu_1 \frac{d}{d\lambda_1} + \ldots + \mu_6 \frac{d}{d\lambda_6}\right)^2 f + x(q_1\mu_1^2 + \ldots + q_6\mu_6^2).$$

Regarding $\beta_1, \ldots \beta_6$ as variables, the first member of this equatio equated to zero would denote a certain screw system of the seco degree. If that system were "central" it would possess a certai screw to which the polars of all other screws would be reciprocal, an its discriminant would vanish; but the screw β being absolutely th same as μ, it is plain that the discriminant of the second side must i such case also vanish. We thus see that the ratios of the coefficient of the various powers of x in the following determinant must remai unchanged when one co-reciprocal set of screws is exchanged fo another. In writing the determinant we put 12 for $\frac{d^2 f}{da_1 \cdot da_2}$, &c.

$$\begin{vmatrix} 11 + xp_1, & 12 & , 13 & , 14 & , 15 & , 16 \\ 21 & , 22 + xp_2, & 23 & , 24 & , 25 & , 26 \\ 31 & , 32 & , 33 + xp_3, & 34 & , 35 & , 36 \\ 41 & , 42 & , 43 & , 44 + xp_4, & 45 & , 46 \\ 51 & , 52 & , 53 & , 54 & , 55 + xp_5, & 56 \\ 61 & , 62 & , 63 & , 64 & , 65 & , 66 + xp_6 \end{vmatrix} = 0$$

ake for instance the coefficient of x^5 divided by that of x^6, which ily seen to be

$$\frac{1}{p_1}\cdot\frac{d^2f}{da_1^2}+\quad .\quad .\quad .\quad +\frac{1}{p_6}\cdot\frac{d^2f}{da_6^2};$$

ve learn that this expression will remain absolutely unaltered led that we only change from one set of co-reciprocals to another. is f is perfectly arbitrary. Let us take it for instance to be the ion R, or the square of the intensity, and we see that

$$\frac{1}{p_1}+\frac{1}{p_2}+\frac{1}{p_3}+\frac{1}{p_4}+\frac{1}{p_5}+\frac{1}{p_6}$$

be an absolute constant so long as we are only concerned with a of co-reciprocal screws. It is easily shown that this constant is and thus we have a theorem otherwise proved in *Screws*, p. 149, f which the present theory may be regarded as a generalization. t will be readily seen that numerous results can be obtained from ifferent coefficients of the powers of x, the absolute term being stance the Hessian. The functions added to the emanants might e an arbitrary factor multiplied into R. Indeed if the discrimi- were formed of the function

$$\left(\beta_1\frac{d}{da_1}+\ldots+\beta_6\frac{d}{da_6}\right)^2 f+x(p_1\beta_1^2+\ldots+p_6\beta_6^2)$$
$$+y(\beta_1^2+\ldots\beta_6^2+\ldots 2\beta_1\beta_2(12))$$

uld be easy to show that the ratios of the coefficients must be in- ndent of the screw of reference so long as they were co-reciprocal, hus a multitude of functions of f would be obtained which retain form so long as the screws of reference are co-reciprocal. We t even discard this last condition by writing for the factor multi- by x the most general value of the pitch multiplied by the square e intensity.

XC.—Notes on the Flora of Lambay Island, County of
By H. C. Hart, B.A.

[Read, November 13, 1882.]

The Island of Lambay is situated off the east coast of Du distance of two and a-half miles from the nearest land at It is somewhat hexagonal in shape, and contains an area of of which only a small part is under cultivation. The wes cultivated portion of the island, which is devoted to dairy fa the butter of Lambay is famed for its excellence.

From Lambay Head, the eastern extremity, to the poin Talbot's Bay on the west, is a distance of a mile and two-th the island is about a mile across from north to south in seve

With the exception of a small strip of land at the harb west, the coast is for the most part precipitous. From th side the island rises to a height of a little over four hundred most of its eastern side is bound with cliffs from two to thre feet high. These cliffs are favourite breeding places for seve of sea-fowl, which resort here in great numbers from May t Here, also, the raven and peregrine-falcon breed annually. is well stocked with rabbits, which are preserved by the ow Talbot de Malahide. There are three families on Lambay, a an old castle, at one time the residence of Archbishop Ussher, through the kindness of Mr. Dillon, the agent for the prope enabled to obtain accommodation during my visit.

Lambay is principally composed of porphyritic felstone Silurian age, and is of much geological interest. Graptolites fossils have been obtained, and there is a remarkable exposu glomerate lying below a sheet of Old Red Sandstone at sea inside Scotch Point. The formation of Lambay is, probably, c with that of the shore south of Portrane, near the Martello T

Besides many former visits of a day's duration, I spent in the summer of 1881 on Lambay, and a similar time in the the present year. During my last visit I had the compa friend Mr. Richard Barrington, whose assistance rendered satisfied that the work was thoroughly done.

Owing to the absence of sandy shores or salt marshes, the smallest quantity, several common maritime plants do n in the flora. Again, with the exception of a couple of wells or three small rivulets, there is no abode for marsh or aquat which are, accordingly, very poorly represented. On the ot some local species grow here in great abundance, while visit early season are astonished by the extraordinary profusion showy flowers which, in their turn, deck the island with red and pink, mauve, white, and yellow. These are chiefly

rimroses, sea pink, red campion, sea campion, and sea feverfew. The undance of red campion is a highly noticeable feature in Lambay.

It might appear that an island so well known and easy of access om Dublin as Lambay would be devoid of fresh interest, especially it has been always a favourite resort for naturalists. To show that is is not the case, I will enumerate some rare or local plants which ave not been previously noticed upon the island, and serve to show e interesting nature of its flora.

Arabis thaliana.
Parnassia palustris.
Geranium pusillum.
Erodium maritimum.
Trifolium striatum.
Vicia lathyroides.
Œnanthe crocata.
Torilis nodosa.
Apium graveolens.
Myosotis collina.
†*Hyoscyamus niger.*
Statice occidentalis.
Scilla verna.
†*Iris fœtidissima.*
Blysmus rufus.
Carex vulpina.
,, *extensa.*
Ophioglossum vulgatum.
Polypodium vulgatum, var. *semi-lacerum.*

Of the above, *Geranium pusillum* is the rarest; a single habitat in lare, and a couple in Antrim, are the only certainly-known Irish calities for this plant, and its occurrence in Lambay is, therefore, ghly important. *Iris fœtidissima* grows on cliffs covered with vegetion in three or four patches near one another on the north side of e island: this station is quite apart from cultivation, nor does the ant occur about the castle, or cottages, or elsewhere upon the island. is a native plant all along the west of England, as far north as urham, and belonging as it does to Mr. Watson's English type of stribution, which is well represented upon Lambay, it is, perhaps, reasonable to challenge it. It occurs in considerable quantity in veral places upon Howth and upon Ireland's Eye, but always near uses, as if introduced, and the bright-coloured seeds may, perhaps, ve been carried from there to Lambay by birds. Mr. More does t believe it to be native in Ireland. *Trifolium striatum*, a very rare ant in Ireland, is plentiful on Lambay, where it appears to have en mistaken for *T. maritimum*. The lover of ferns will find, too, a ndsome variety of the Polypody, *Polypodium semi-lacerum*, upon the me banks as the *Iris fœtidissima*.

The luxuriance of showy flowers has already been mentioned; the undance of some either local or less common species is also a feature interest. *Myosotis collina* is very abundant all round the margin, a ttle inside the rocky coast, while on the rocks themselves *Inula crithoides* and *Crithmum maritimum* occur plentifully; *Scilla verna* forms he sod in many places, as at Scotch Point, near the sea; *Erodium aritimum* covers the ground with closely prostrate growth, especially n the dry, sandy soil about the rabbit-warren on the southern side; n thickets of brambles on the northern side of the island *Agrimonia*

eupatorium is unusually common, while in similar situation
cliffs on the east, *Arum maculatum* is plentiful.

One of the most interesting "finds" I made on Lamba
of an extraordinary luxuriant growth of *Ophioglossum vulga*
eastern end of the island, about a hundred and fifty yards inl
wards from Freshwater Bay, at the east side of the stream.
extends over more than an acre and a-half of ground, and is
grown that a sod of six inches square will often contain ov
fronds.

There is a distinct preference shown by several speci
southern shores of the island, or it might be nearer the tr
that these, as a rule, avoid the northern coast from Lamba
Scotch Point: these are—

Viola hirta.	*Cynoglossum officin*
Geranium sanguineum.	*Lycopsis arvensis.*
Erodium maritimum.	*Statice occidentalis.*
Trifolium striatum.	*Beta maritima.*
Leontodon hirtus.	*Arum maculatum.*

This preference is due, no doubt, to some superiority of
climate, since the situations are in other respects similar. E
negative one, the north side has no characteristic peculiar
flora. It must be borne in mind that all the botanical inter
island lies around the margin.

There are no indigenous trees upon Lambay; sycamore, a
and hawthorn have been introduced in the neighbourhood of
but these have hardly spread themselves. Elder, blackt
perhaps one sallow appear to be the only native shrubs. Fu
in a naturalized state, having spread to wild stations at the e
and about Raven's Rock; it was, however, introduced for fe
poses about twenty-five years ago, as I am informed by Mr
the caretaker. Brambles form a dense and tangled under
many parts of the island to the exclusion of other species.

The absence of several plants which are abundant on
promontory eight or ten miles from Lambay, with a similar
be noticed. Amongst these are *Sarothamnus scoparius*, *Ule.*
and *U. nanus*, *Ononis arvensis*, *Artemisia vulgaris*, *Senecio*
Salix repens, &c.

I am confident that few plants have escaped my repeate
over the island; nevertheless, the absence of some common
unexpected, for example:—

Stellaria holostea.	*Pedicularis sylvatic*
Bunium flexuosum.	*Carex stellulata.*
Daucus carota.	*C. trinervis.*
Achillea millefolium.	*Blechnum boreale.*
Chrysanthemum leucanthemum.	

e Lambay flora is a very natural one; there is little cultivation, e introduced plants are few in number, sparingly established, I think, easily detected. Disregarding several sub-species or es, the flora consists of 291 flowering plants and ferns, of which ies are probably not native.

FLORA OF LAMBAY.

RANUNCULACEÆ.

ulus hederaceus (Linn.)—Raven's Well, and by the castle.
mula (Linn.)—Frequent.
ns (Linn.)—Common.
osus (Linn.)—About Scotch Point and elsewhere.
s (Linn.)—Frequent.
ia (Linn.)—Common round the coast.
palustris (Linn.)—Raven's Well.

PAPAVERACEÆ.

r somniferum (Linn.)—Below Coastguard Station, an escape.]
as (Linn.)—Cultivated fields near the harbour.
ium (Linn.)—Do.

FUMARIACEÆ.

ia officinalis (Linn.)—Cultivated ground near the harbour.

CRUCIFERÆ.

maritima (Scop.)—Sparingly south of harbour.
us raphanistrum (Linn.)—On the shore near the Coastguard tion, very closely approaching *R. maritimus.*
s arvensis (Linn.)—Cultivated ground and waste places near castle.
(Linn.)—With the last, scarce.
rium officinale (Scop.)—Borders of fields, pathways, &c.; proly native, but not plentiful.
ine pratensis (Linn.)—Above Calico Bay.
uta (Linn.)—In several places.
thaliana (Linn.) Banks above the sea at Broad Bay and lap. This is a rare and very local plant in Ireland. In the nty Dublin I have only met with it upon Howth.
tium officinale (Brown.)—In two or three places by the brooks.
ria officinalis (Linn.)—Common.
verna (Linn.)—I believe I gathered withered stalks of this ies, but am not certain.
arvense (Linn.)—A colony appeared in enclosed ground at castle, 1882.
s bursa-pastoris (Moench.)—Frequent.
a coronopus (Poir.)—By the harbour and cottages.

Resedaceæ.

‡*Reseda luteola* (Linn.)—Sparingly near the castle, and by t
the field between it and Saltpan Bay.

Violaceæ.

Viola hirta (Linn.)—Near the sea at Gouge Point; betwee
Head and Sunk Island, near the sea in two places; b
close to the castle, and elsewhere. Chiefly on the sout
of island.

V. sylvatica (Fries.)—Frequent. Chiefly *V. reichenbachiana.*

V. tricolor (Linn.)—Cultivated fields.

Polygalaceæ.

Polygala vulgaris (Linn.)—Common. Var. *depressa* (Wend
at Raven's Rock.

Caryophyllaceæ.

Silene maritima (With.)—Abundant.

Lychnis diurna (Sibth.)—Covers many parts of the island
rose-coloured blossoms in the earliest summer, especiall
the thickets of blackberry a little inland.

L. flos-cuculi (Linn.)—By the stream into Carnoon Bay.

Cerastium tetrandrum (Curt.)—Pilots' Hill, &c.

C. glomeratum (Thuil.)—Banks by the sea on the north side.

C. triviale (Link.)—Common.

C. arvense (Linn.)—Plentiful.

Stellaria media (With.)—Frequent.

S. graminea (Linn.)—South-east side of Heath Hill, near th

S. uliginosa (Murr.)—Raven's Well.

Honckenya peploides (Ehr.)—Sparingly near the harbour.

Sagina maritima (Don.)—Frequent; Scotch Point, &c.

S. procumbens (Linn.)—Frequent.

‡*Spergula arvensis* (Linn.)—Cultivated fields, frequent.

Lepigonum rupicola (More.)—Frequent.

Hypericaceæ.

Hypericum tetrapterum (Fries.)—In several places.

H. pulchrum (Linn.)—West side of island near the castle.

Malvaceæ.

Malva sylvestris (Linn.)—Frequent.

Linaceæ.

Linum catharticum (Linn.)—Common.

GERANIACEÆ.

-anium sanguineum (Linn.)—On south and west side of island; north of Raven's Well.

molle (Linn.)—Frequent.

pusillum (Linn.)—I discovered a considerable quantity of this plant, one of the rarest in Ireland, at the south-west corner of the large field north of the castle.

dissectum (Linn.)—Frequent by the coast to the south of the harbour and elsewhere.

robertianum (Linn.)—In stony places behind the castle, sparingly.

-dium cicutarium (Herit.)—Frequent.

maritimum (Sm.)—Especially abundant about the rabbit-warren at the south of the island; it forms a green sward frequently round the rabbit-holes, and appears to be the only plant permitted to do so. Frequent all round Lambay, except on the northern face, where it seems hardly able to exist.

-lis acetosella (Linn.)—Sparingly in shady ground near the castle.

LEGUMINOSÆ.

-ex europæus (L.)—Introduced for fencing purposes, about twenty-five years ago. It has spread to wild stations on the eastern side, and about Raven's Rock.

-thyllis vulneraria (Linn.)—Frequent.

-dicago lupulina (Linn.)—By a cottage, and on the borders of the large field north of the castle.

-ifolium pratense (Linn.)—Common, and I believe native on grassy banks by the sea.

arvense (Linn.)—Along the shore from the harbour to Scotch Point, and along the north side of the island in several places; not common.

striatum (Linn.)—Plentiful in pasturage above the harbour and along the shore to Scotch Point; east of the castle above a cottage and by the shore a little south of harbour beyond the Coastguard Station. In the "Flora Hibernica" *Trifolium maritimum* is said to grow on Lambay; probably the present species was mistaken for it.

repens (Linn.)—Frequent.

minus (Sm.)—Frequent.

-tus corniculatus (Linn.)—Common.

-cia hirsuta (Koch.)—South-west side of island by the shore, and in cultivated fields near the Coastguard Station.

-icia cracca (Linn.)—Banks by the shore at Talbot's Bay.

sepium (Linn.)—Frequent.

angustifolia (Roth.)—By the shore south of harbour, &c.; east coast of Lambay.

lathyroides (Linn.)—Under Tinian Hill, above the sea, on the east side of Lambay.

**Vicia sativa* (Linn.)—In several places amongst cultivated gro
Lathyrus pratensis (Linn.)—Scarce; above the sea at Calic and on dry, hilly ground south-east from the castle.

ROSACEÆ.

Prunus spinosa (Linn.)—South-east from the castle, not comm
Spiræa ulmaria (Linn.)—By the sides of the rivulets.
Agrimonia eupatoria (Linn.)—Very abundant in several places
Alchemilla arvensis (Scop., Linn.)—Common.
Potentilla tormentilla (Schenk.)—Frequent.
P. reptans (Linn.)—Frequent.
P. anserina (Linn.)—Frequent.
Fragaria vesca (Linn.)—Frequent at the south-west part island.

Rubus carpinifolius (W. & N.)
R. villicaulis (W. & N.)
} These appeared to me to be the of brambles met with, the being very abundant.

Rosa spinosissima (Linn.)—Common.
R. canina (Linn.)—Frequent.
**Cratægus oxyacantha* (Linn.)—Not native.

LYTHRACEÆ.

Lythrum salicaria (Linn.)—By the sides of streams.

ONAGRACEÆ.

Epilobium hirsutum (Linn.)—Near the castle in two or three pla
E. parviflorum (Schreb.)—In several places.
E. palustre (Linn.)—Raven's Well, very sparingly.

HALORAGACEÆ.

Callitriche verna (Linn.)—Trinity Well, &c. Var. *platycarpa* (Sc Frequent.

CRASSULACEÆ.

Sedum anglicum (Huds.)—Common.
S. acre (Linn.)—Common.

SAXIFRAGACEÆ.

Parnassia palustris (Linn.)—Sparingly by the stream into Freshw Bay about fifty yards from the cliffs, and at Raven's Well.

UMBELLIFERÆ.

Hydrocotyle vulgaris (Linn.)—By the rivulets.
Eryngium maritimum (Linn.)—At the harbour.

ı.graveolens (Linn.)—South-west shores of island, in plenty at lbot's Bay.
iadium nodiflorum (Koch.)—Frequent.
odium podagraria (Linn.)—Garden-ditch at the castle.
the lachenalii (Gmel.)—Talbot's Bay.
ocata (Linn.)—At a well below the cottage a little south of wen's Rock; on a bank behind the cottage immediately above e castle; and in a deep ditch south-east from the castle.
ıa cynapium (Linn.)—Near the castle.
num maritimum (Linn.)—Abundant.
ica sylvestris (Linn.)—Near the castle and elsewhere.
leum sphondylium (Linn.)—Very abundant on cliffs at Saltpan y and elsewhere.
ı nodosa (Gaert.)—In the same locality as *Geranium pusillum*.
phyllum sylvestris (Linn.)—Shady ground about the castle.
n maculatum (Linn.)—By the shore on the south-west side of e island; apparently native a little north of Raven's Well on e hill side; and near the castle.

ARALIACEÆ.

ı helix (Linn.)—Frequent.

CAPRIFOLIACEÆ.

cus nigra (Linn.)—A characteristic plant, and the only conspi- ous native shrub on Lambay. Abundant on banks above Broad y and Saltpan Bay; Knockbane; Seal hole, &c.
ra periclymenum (Linn.)—Frequent.

RUBIACEÆ.

ı saxatile (Linn.)—Heath Hill, &c.; not common.
um (Linn.)—Frequent.
rine (Linn.)—Frequent, especially among shingle on the shore the south-west.
dia arvensis (Linn.)—Cultivated field south of castle.

DIPSACEÆ.

ıa succisa (Linn.)—Very common.

COMPOSITÆ.

us tenuiflorus (Curt.)—Common.
ceolatus (Linn.)—Frequent.
ustris (Linn.)—Frequent.
ensis (Curt.)—Frequent.
a vulgaris (Linn.)—Frequent.
m intermedium (Lange.)—Frequent.
rea nigra (Linn.)—Frequent.

or three places on the north side.

Senecio vulgaris (Linn.)—Frequent.

S. jacobæa (Linn.)—Frequent.

Inula crithmoides (Linn.)—Common on most of
northern side.

I. pulicaria (Linn.)—In damp places; frequent

Bellis perennis (Linn.)—Frequent.

Aster tripolium (Linn.)—Only at the south-wes

Tussilago farfara (Linn.)—In several places.

Eupatorium cannabinum (Linn.)—Gillap on the
seal-hole on the south-east side.

†*Lapsana communis* (Linn.)—Cultivated ground c

Hypochæris radicata (Linn.)—Common.

Leontodon hirtus (Linn.)—By the shore on the
west side of island.

L. autumnalis (Linn.)—Common.

Taraxacum officinale (Wigg.)—South and west s

Sonchus oleraceus (Linn.)
S. asper (Hoffm.)
S. arvensis (Linn.)
} Frequent; *S. arven*
situation on the s

Hieracium pilosella (Linn.)—Common.

CAMPANULACEÆ.

Jasione montana (Linn.)—Rocky ground at Gill

Campanula rotundifolia (Linn.)—Frequent.

ERICACEÆ.

Erica cinerea (Linn.)—Common.

Calluna vulgaris (Salist.)—Common.

NOTE.—*Erica tetralix,* which is not upon
moister climate and a greater extent of mount
the above species; it is, certainly, more local

GENTIANACEÆ.

rythræa centaurium (Pers.)—Var. *pseudo-latifolia*. Frequent.

SOLANACEÆ.

Solanum dulcamara (Linn.)—By the rivulet into Carnoon Bay.
Hyoscyamus niger (Linn.)—A good-sized patch near the seal-hole on the south-east side of the island.

SCROPHULARIACEÆ.

Scrophularia nodosa (Linn.)—Very sparingly in Thornchase Valley.
Veronica hederifolia (Linn).—Ditch-banks of the large field north of castle and below coastguard station.
V. polita (Fries.), *V. agrestis* (Linn.)—Below the Coastguard Station and near the cottages in two or three places, but apparently introduced.
V. buxbaumii (Ten.)—By a cottage east of the castle.
V. arvensis (Linn.)—Common.
V. serpyllifolia (Linn.)—Near the castle, &c.
V. officinalis (Linn.)—Common.
V. chamædrys (Linn.)—Common.
V. anagallis (Linn.)—In a deep ditch south-east from the castle.
V. beccabunga (Linn.)—Frequent.
Euphrasia officinalis (Linn.)—Very scarce, Raven's Rock only.
Bartsia odontites (Huds.)—Frequent about cultivation.
Rhinanthus crista-galli (Linn.)—A few plants on the border of a field near the castle.

LABIATÆ.

Mentha hirsuta (Linn.)—Frequent.
Thymus serpyllum (Fries.)—Common.
Nepeta glechoma (Benth.)—Common.
Prunella vulgaris (Linn.)—Common.
Galeopsis tetrahit (Linn.)—Cultivated fields.
Lamium amplexicaule (Linn.)—Cultivated ground near the Coastguard Station.
L. incisum (Willd.)—Near the Coastguard Station, and by a cottage, east from the castle.
L. purpureum (Linn.)—About the castle.
Teucrium scorodonia (Linn.)—Common.

BORAGINACEÆ.

Myosotis cæspitosa (Schultz.)—By a rivulet a little south of the castle.
M. palustris (With.)—In one deep ditch south-east from the castle.
M. arvensis (Hoffm.)—South and east side of island.
M. collina (Reich.)—Very abundant all round the island, though not occuring far from the sea. A characteristic feature in the Lambay Flora.

Myosotis versicolor (Reich.)—Frequent.
Lycopsis arvensis (Linn.)—Chiefly on the south-east
**Symphytum officinale* (Linn.)—On a ditch-bank b cottage.
Cynoglossum officinale (Linn.)—South-east side of th sea.

PRIMULACEÆ.

Primula vulgaris (Huds.)—Common.
P. veris (Linn.)—Near Trinity Well, and in a mead (Miss Monks.)
Anagallis arvensis (Linn.)—About rabbit burrows n quent. Also in cultivated fields.
A. tenella (Linn.)—About the Raven's Well.
Glaux maritima (Linn.)—South-west shore, Carn Bay.
Samolus valerandi (Linn.)—Not unfrequent.

PLUMBAGINACEÆ.

Armeria maritima (Willd.)—Common.
Statice occidentalis (Lloyd.)—Rocky coast south- Head. About Tayleur Bay.

PLANTAGINACEÆ.

Plantago major (Linn.)—About the castle.
P. lanceolata (Linn.)—Common.
P. maritima (Linn.)—Common.
P. coronopus (Linn.)—Common.

CHENOPODIACEÆ.

Salsola kali (Linn.)—Near the harbour.
Beta maritima (Linn.)—Abundant on the southern
‡*Chenopodium album* (Linn.)—Cultivated and waste g
Atriplex angustifolia (Sm.)—Talbot's Bay, &c.
A. deltoidea (Bab.)—Talbot's Bay, &c.
A. babingtonii (Woods.)—Frequent.
A. littoralis (Linn.)—A little south of the castle. with this plant during my last visit to Lamba in 1881.

POLYGONIACEÆ.

Polygonum aviculare (Linn.)—Frequent
P. raii (Bab.)—Near the north of the harbour.
P. persicaria (Linn.)—Frequent.

EUPHORBIACEÆ.

‡*Euphorbia helioscopia* (Linn.)—Cultivated fields near the castle.
‡*E. peplus* (Linn.)—Cultivated fields near the castle.

URTICACEAE.

Urtica dioica (Linn.)—The nettles in Saltpan Bay are ranker and more venomous than any I ever met with; the effects of their stings do not pass off for a couple of days.
‡*U. urens* (Linn.)—In several places.

AMENTIFERÆ.

‡*Salix viminalis* (Linn.)—Near the castle, but probably introduced.
†*S. cinerea* (Linn.)—Near the castle, perhaps introduced.

ARACEÆ.

Arum maculatum (Linn.)—South and south-east sides near the sea. Common.

LEMNACEÆ.

Lemna minor (Linn.)—Raven's Well.

NAIADACEÆ.

Zostera marina (Linn.)—Low water at spring-tides a little south of the harbour.

ALISMACEÆ.

Triglochin palustre (Linn.)—Sparingly at Bishop's Bay.
T. maritimum (Linn.)—Sparingly at Bishop's Bay.

ORCHIDACEÆ.

Orchis latifolia (Linn.)—One plant at Raven's Well, where it was detected by Mr. Barrington; but Miss Monks assured me it was usually plentiful there.

IRIDACEÆ.

†*Iris fœtidissima* (Linn.)—Banks above Saltpan Bay in three places, and at the shore level. See introduction.
†*Iris pseudacorus* (Linn.)—Bishop's Bay on the southern side. I have appended the mark of suspicion in deference to the opinion of Mr. Moore.

LILIACEÆ.

Scilla verna (Huds.)—Abundant on dry grassy banks on the westward side of the island and elsewhere.

Scilla nutans (Sm.)—Very abundant on Lambay, and lendin to the slopes in the spring. The white variety of th occurs rarely.

JUNCACEÆ.

Luzula campestris (W. C.)—Frequent.
Juncus maritimus (Sm.)—South-west side, at Carnoon Bay ar Bay.
J. conglomeratus (Linn.)—East side of Lambay.
J. glaucus (Sibth.)—By the rivulet into Freshwater Bay, a south-east side.
J. acutiflorus (Ehrh.)—Frequent.
J. lamprocarpus (Ehrh.)—At Scotch Point.
J. supinus (Mœnch.)—About the castle.
J. bufonius (Linn.)—Frequent.
J. gerardi (Lois.)—(*J. compressus*, Jacq. var.) Carnoon Bay

CYPERACEÆ.

Schœnus nigricans (Linn.)—Talbot's Bay and Carnoon Bay.
Blysmus rufus (Link.)—Carnoon Bay; first observed by Mr. B
Scirpus savii (S. & M.)—Raven's Well; stream into Freshw south-west side of island.
Eriophorum angustifolium (Roth.)—Raven's Well.
Carex disticha (Huds.)—By Freshwater Bay brook, and i marshes at the west side.
C. arenaria (Linn.)—Carnoon Bay and Bishop's Bay.
C. vulpina (Linn.)—Bishop's Bay
C. vulgaris (Fries.)—Pilot's Hill.
C. glauca (Scop.)—In several places.
C. præcox (Jacq.)—Frequent, chiefly by the coast.
C. panicea (Linn.)—Marshy ground east of Knockbane.
C. distans (Linn.)—Common on the south and west shores.
C. extensa (Good.)—Carnoon Bay, and elsewhere on the s shore.
C flava (Linn.)—By the stream into Freshwater Bay.
C. hirta (Linn.)—Raven's Well, and in several places near t

GRAMINEÆ.

Anthoxanthum odoratum (Linn.)—Common.
Digraphis arundinacea (Trin.)—Sparingly by a heavy dit east from the harbour.
†*Alopecurus pratensis* (Linn.) } Fields about the castle.
‡*Phleum pratense* (Linn.) }
Agrostis vulgaris (With.)—Frequent.
A. alba (Linn.)—Frequent.
A. canina (Linn.)—Frequent.
Aira flexuosa (Linn.)—Frequent.
†*A. cæspitosa* (Linn.)—Frequent.
A. caryophyllea (Linn.)—Frequent.

præcox (Linn.)—Frequent.
enatherum avenaceum (Beauv.)—Common.
us mollis (Linn.)—Northern coast, in two or three places.
natus (Linn.)—Frequent.
lia decumbens (Beauv.)—Hilly ground behind the castle.
nia cærulea (Mœnch.)—Scarce, a little east from the castle.
eria fluitans (Brown.)—By the stream into Freshwater Bay.
ochloa maritima (Lindl.)—Frequent.
gida (Link.)—Walls of castle, farm-yard, and pier-wall.
annua (Linn.)—Frequent.
ratensis (Linn.)—In several places.
ivialis (Linn.)—Near the castle.
a media (Linn.)—A little west of the harbour.
surus cristatus (Linn.)—Frequent.
ylis glomerata (Linn.)—Frequent.
ca sciuroides (Roth.)—Walls by the castle; shore between chapel and Coastguard Station.
ina (Linn.), et *F. duriuscula* (Linn.)—Frequent.
atior (Linn.)—South-west side at Carnoon Bay.
us mollis (Linn.)—Common.
hypodium sylvaticum (R. & S.)—Frequent along the southern cliffs.
cum repens (Linn.)—Carnoon Bay.
nceum (Linn.)—Near the harbour.
um perenne (Linn.)—Frequent.
lus stricta (Linn.)—Frequent.

FILICES.

s aquilina (Linn.)—Frequent.
nium marinum (Linn.)—New House; Tayleur Bay; Saltpan Bay.
liantum nigrum (L.)—Rocky places about the castle; Calico Bay; Lambay Head.
rium filix-fœmina (Bernh.)—Near Raven's Well; north side of Knockbane.
pendrium vulgare (Sm.)—Calico Bay and Saltpan Bay.
dium angulare (Willd.)—Grassy cliffs above Calico Bay; rocky places above the castle.
ea filix-mas (Presl.)—North side of island at Knockbane, &c.
lata (Presl.)—Sparingly by the sea in Saltpan Bay.
podium vulgare (Linn.)—Common on the north side; the variety *semi-lacerum* occurs at Calico Bay. This is the form that is usually called *P. cambricum* in Ireland, from which it differs in bearing copious fructification and in other respects. I mention this to correct the statement made in the "Catalogue of Dublin and Wicklow Plants," that *P. cambricum* occurs in the Dargle. The Dargle fern is *P. semi-lacerum*, and I doubt if true *P. cambricum* has ever been gathered in Ireland. My brother, Mr. G. V. Hart, who has long cultivated the Irish ferns, has never met with it.

of interest. Reliable means for such a comp
Mr. More's "Report on the Flora of Inish-B
island which lies almost exactly in the same la
Ireland as Lambay does upon the east. These
of limestone, and there is no geological diss
entail any important difference in their floras.
alike in character, and their difference in eleva
being about a hundred feet higher than Inish-B
however, about four times the area of Lambay,
has also a great superiority in possessing "fou
pools with a considerable extent of moist and b
a fair proportion of water plants, sedges, rushes
we have seen, neither lake nor turf-bog, and ve
for any of the marsh or aquatic species. The
pose to draw has for its object the illustration o
from the climates of the two coasts, and geo
Probably these influences alone are the causes
bay plants do not or could not exist upon Inish
hand many of the Inish-Bofin plants which do n
are absent, in all likelihood, simply from surfa
want of sufficient water.

Prominent amongst them are :—

Ranunculus heterophyllus, et vars., *Potamoget*
Drosera rotundifolia, *P. natans.*
Myriophyllum alterniflorum, *P. polygon*
Galium palustre, *Phragmite*
Montia fontana, *Eleocharis*
Menyanthes trifoliata, *Carex amp*
Polygonum amphibium, *Equisetum*
Narthecium ossifragum,

These are all found—for instance, upon the ad

laid particular stress upon "the absence of turfy bogs and scarcity f damp ground which entails a great want of marsh and heath plants, edges, and rushes," &c. The result of this is that Mr. More can numerate ninety-two plants upon Bofin which do not occur upon ran, against 161 Aran plants which are absent from Bofin. Of these, he majority are, in all probability, absent from Aran in consequence of his accidental want of marshy ground and in no respect from climate, eological structure, or geographical situation. The omission of this onsideration renders the contrast between the two floras less strikingly n favour of the Aran limestone flora than it may be fairly estimated y attaching weight to the absence of unimportant plants.

Mr. More enumerates 303 varieties, or, say 295 species, as found upon Inish-Bofin. My Lambay list contains 291 species. Deducting from each of these totals those plants which are probably introduced, there remain 252 native species for Bofin, 258 for Lambay. Considering the superior size of Inish-Bofin and its much more diversified surface-conditions, the majority in favour of Lambay illustrates well the richer flora of the east of Ireland. A few plants, such as *Sisymbrium officinale*, *Capsella bursa-pastoris*, *Galium aparine*, and three species of trefoil are, I believe, native on Lambay, though most likely nly colonists in the far west of Ireland.

In the following comparative lists several commoner aquatic species lready mentioned are omitted from the Bofin plants, as not tending o illustrate the essential differences between the two floras:—

COMPARATIVE VIEW OF FLORAS OF INISH-BOFIN AND LAMBAY,

Including only Plants probably native.

ambay Plants not on Inish-Bofin.	**Inish-Bofin Plants not on Lambay.**
RANUNCULACEÆ.	
Ranunculus ficaria. *Caltha palustris.*	
NYMPHÆACEÆ.	
	Nuphar luteum.
CRUCIFERÆ.	
Sisymbrium officinale. *Arabis thaliana.* *Draba verna.*	
CISTACEÆ.	
	Helianthemum guttatum.
VIOLACEÆ.	
Viola hirta. *V. tricolor.*	*Viola palustris.* *V. canina.*

Lambay Plants not on Inish-Bofin.	**Inish-Bofin Plants not on**
POLYGALACEÆ.	
Polygala vulgaris, typ.	
ELATINACEÆ.	
	Elatine hexandra.
CARYOPHYLLACEÆ.	
Lychnis diurna. *Cerastium arvense.* *Stellaria media.* *S. graminea.* *S. uliginosa.* *Honckenya peploides.* *Sagina maritima.*	*Spergularia salina.*
LINACEÆ.	
	Radiola millegrana.
HYPERICACEÆ.	
	Hypericum androsæm *H. elodes.*
GERANIACEÆ.	
Geranium sanguineum. *G. pusillum.* *G. dissectum.* *Erodium maritimum.*	
LEGUMINOSÆ.	
Trifolium repens. *T. pratense.* *T. minus.* †*Vicia hirsuta.* *V. lathyroides.*	Mr. More considers th clovers as probably intro Inish-Bofin.
ROSACEÆ.	
Fragaria vesca. *Alchemilla arvensis.* *Agrimonia eupatorium.*	*Comarum palustre.*
ONAGRACEÆ.	
Epilobium hirsutum.	*Epilobium montanum* *E. tetragonum.*
LYTHRACEÆ.	
	Peplis portula.

Lambay Plants not on Inish-Bofin.	Inish-Bofin Plants not on Lambay.
SAXIFRAGACEÆ.	
Parnassia palustris.	*Saxifraga umbrosa.*
CAPRIFOLIACEÆ.	
Sambucus nigra.	
UMBELLIFERÆ.	
Eryngium maritimum.	*Daucus carota.*
Apium graveolens.	*Helosciadium inundatum.*
Helosciadium nodiflorum.	
Œnanthe lachenalii.	
Œ. crocata.	
Torilis nodosa.	
Chærophyllum sylvestre.	
Conium maculatum.	
RUBIACEÆ.	
Galium aparine.	
COMPOSITÆ.	
Carduus tenuiflorus.	†*Centaurea scabiosa.*
Carlina vulgaris.	*Gnaphalium uliginosum.*
Filago germanica.	*Senecio sylvaticus.*
Inula crithmoides.	*Achillea ptarmica.*
Eupatorium cannabinum.	*A. millefolium.*
CAMPANULACEÆ.	
	Lobelia dortmanna.
ERICACEÆ.	
	Erica tetralix.
GENTIANACEÆ.	
	Gentiana campestris.
CONVOLVULACEÆ.	
	Convolvulus sepium.
SOLANACEÆ.	
Solanum dulcamara.	
Hyoscyamus niger.	

Lambay Plants not on Inish-Bofin.	**Inish-Bofin Plants not on**
SCROPHULARIACEÆ.	
Scrophularia nodosa. †*Veronica hederifolia.*	*Rhinanthus crista-ga* *Pedicularis palustri* *P. sylvatica.* *Scrophularia aquati*
LABIATÆ.	
Nepeta glechoma. †*Lamium incisum.* †*L. purpureum.*	*Stachys palustris.* *Scutellaria minor.*
BORAGINACEÆ.	
Myosotis palustris. *M. collina.* *M. versicolor.* *Lycopsis arvensis.* *Cynoglossum officinale.*	
LENTIBULARINEÆ.	
	Pinguicula vulgaris
PRIMULACEÆ.	
Primula veris. *Anagallis arvensis.*	*Centunculus minim*
PLUMBAGINACEÆ.	
Statice occidentalis.	
PLANTAGINACEÆ.	
	Litorella lacustris.
CHENOPODIACEÆ.	
Beta maritima. *Atriplex littoralis.*	
POLYGONACEÆ.	
Rumex nemorosus. *Polygonum raii.*	*Polygonum hydropi*
EMPETRACEÆ.	
	Empetrum nigrum.
CALLITRICHACEÆ.	
	Callitriche hamulata

ambay Plants not on Inish-Bofin.		Inish-Bofin Plants not on Lambay.
	URTICACEÆ.	
Urtica dioica.		
	AMENTIFERÆ.	
†*Salix cinerea.*		*Populus tremula.* *Salix aurita.* *S. repens.* *Myrica gale.*
	LILIACEÆ.	
Scilla verna. *Scilla nutans.*		
	CONIFERÆ.	
		Juniperus nana.
	ORCHIDACEÆ.	
Orchis latifolia.		*Orchis maculata.*
	IRIDACEÆ.	
Iris fœtidissima.		
	ALISMACEÆ.	
Triglochin maritimum.		
	NAIADACEÆ.	
		Potamogeton pectinatus.
	AROIDEÆ.	
Arum maculatum.		
	TYPHACEÆ.	
		Sparganium affine.
	RESTIACEÆ.	
		Eriocaulon septangulare.
	JUNCACEÆ.	
Luzula campestris. *Juncus maritimus.* *J. glaucus.*		*Luzula multiflora.* *Juncus squarrosus.*

Lambay Plants not on Inish-Bofin.	**Inish-Bofin Plants not on L**
CYPERACEÆ.	
Blysmus rufus.	*Scirpus fluitans.*
Carex disticha.	*Rhynchospora alba.*
C. vulgaris.	*Eleocharis multicaulis.*
C. vulpina.	*Carex pulicaris.*
C. hirta.	*C. stellulata.*
	C. binervis.
GRAMINEÆ.	
Digraphis arundinacea.	*Psamma arenaria.*
†*Alopecurus pratensis.*	*Calamagrostis epigejos.*
†*Aira cæspitosa.*	*Kœleria cristata.*
Holcus mollis.	*Sclerochloa loliacea.*
Sclerochloa rigida.	*Festuca pratensis.*
Briza media.	
Festuca sciuroides.	
Triticum junceum.	
FILICES.	
Scolopendrium vulgare.	*Asplenium ruta-muraria*
Aspidium angulare.	*Blechnum boreale.*
Ophioglossum vulgatum.	*Lastræa æmula.*
	Osmunda regalis.
LYCOPODIACEÆ.	
	Isoetes echinospora.

Thus Lambay contains ninety-one, and Inish-Bofin sixty-fo racteristic peculiar plants. In order to understand more thor the different natures of the two floras, I will arrange them ac to Mr. Watson's types. The Lambay flora will be found to forty-nine species of the British or commonest type not occurrin Bofin, as against fifty-five British type plants on Bofin not oc upon Lambay. And this is what might have been foreseen, the island containing the greater variety of common species. Th about one hundred and sixty-five 'British type' species com both islands.

The undermentioned species peculiar to either island bel Watson's English type, or are "inclining to" his English type

LAMBAY.	BOFIN.
Sisymbrium thalianum.	Nuphar lutea.
Viola hirta.	Elatine hexandra.
Cerastium arvense.	Hypericum androsæm
Geranium sanguineum.	H. elodes.

LAMBAY.	BOFIN.
ranium pusillum.	**†Centaurea scabiosa.**
folium striatum.	**Gnaphalium uliginosum.**
arvense.	**Convolvulus sepium.**
minus.	**Scrophularia aquatica.**
rimonia eupatorium.	**Scutellaria minor.**
ilobium hirsutum.	**Centunculus minimus.**
nbucus nigra.	**Calamagrostis epigejos.**
ium graveolens.	**Sclerochloa loliacea.**
losciadium nodiflorum.	
ıanthe crocata.	
lachenalii.	
ilis nodosa.	
patorium cannabinum.	
lina vulgaris.	
duus tenuiflorus.	
anum dulcamara.	
oscyamus niger.	
ıoglossum officinale.	
osotis palustris.	
mula veris.	
ıgallis arvensis.	
a maritima.	
fœtidissima.	
cus glaucus.	
naritimus.	
ım maculatum.	
ex disticha.	
ıirta.	
rochloa rigida.	
za media.	
idium angulare.	

e are, besides, three English, or inclining to English type ommon to both, viz.:—*Vicia augustifolia*, *Lythrum salicaria*, *valerandi*. These columns show well the decrease in numbers ;pe on the western coast—15 to 38, or as 1 to 2½.

in importance is the Atlantic type; its members stand as —

LAMBAY.	BOFIN.
lium maritimum.	Lastræa æmula.
la crithmoides.	
ice occidentalis.	
la verna.	

And five species common to both islands, viz.:—

Lepigonum rupicola.
Sedum anglicum.
Crithmum maritimum.
Scirpus savii.
Asplenium marinum.

This is rather surprising; but it will be found that W
Atlantic or western type is anomalously so-called in Ireland, be
least as well represented on the eastern as on the western co
that the insular floras reveal a somewhat unexpected truth.
are, however, two highly interesting plants upon Inish-Bofin
do not fall under any of Watson's types, *Helianthemum guttatu*
Saxifraga umbrosa. These and others of the so-called Hibernia
which do not occur in Great Britain may be regarded as the ext
group of the Atlantic type in the British Islands.

With Highland and northern plants Lambay is sparingly sup
two species of the latter alone being met with, while nine occur
Bofin.

Lambay.	Bofin.
Parnassia palustris.	Comarum palustre.
Blysmus rufus.	Lobelia dortmanna.
	Gentiana campestris.
	Pinguicula vulgaris.
	Empetrum nigrum.
	Juniperus nana.
	Eriocaulon septangulare.
	Sparganium affine.
	Isoetes echinospora.

This, again, exemplifies the condition of things upon the main
both these types being much better represented and descending l
upon the west than upon the east coast of Ireland, and is due, no d
to the damper and more equal climate. Most of the remaining sp
peculiar to Bofin are more universally prevalent in the west th
the east of Ireland, amongst which may be mentioned:—

Bofin.

Viola palustris.
Achillea ptarmica.
Erica tetralix.
Myrica gale.
Litorella lacustris.
Callitriche hamulata.
Rhynchospora alba.
Eleocharis multicaulis.
Osmunda regalis.

POSTSCRIPT.—Since writing the above, Mr. More has drawn my attention to a paragraph in Dalton's "History of Ireland," where some Lambay plants are enumerated. Amongst these are a few which I did not meet with, and which are probably erroneously included. The records are taken from the "Irish Flora," to which they were, I believe. contributed by Mr. White of Glasnevin. The species are:—

Trifolium maritimum. Probably was *T. striatum.*
T. scabrum. I searched for this plant carefully without success.
Drosera rotundifolia., *Montia fontana.*, *Senecio aquaticus.* — Perhaps lost through drainage.
Œnanthe peucedanifolia. Perhaps *Œ. lachenalii*, which is, however, also mentioned; and
Sambucus ebulus, which is not there now.

XCI.—Report on the Flora of the Mountains of Mayo and G
By H. C. Hart, B. A.

[Read, January 22, 1883.]

Having received a grant from the Royal Irish Academy for th pose of continuing my examination of the Botany of the Irish mo in 1882, I resolved to devote my exertions to those situate in and Galway. In a little less than a month, during two visits i and July, I traversed all the mountains of important height– 2000 feet and upwards. Some were so utterly barren that a visit sufficed. I have, however, taken each chain separately report and dealt with its peculiarities, and will, therefore, enumerate them here, starting at the north-east. The figur the height in feet, from the Ordnance Map.

In Mayo :—

Nephin, 2646.
Knockaffertagh, 1695; Birreencorragh, 2295; and Buckoogh, 19
Laghtdauhybaun, 2369; Corslieve, 1785; Nephinbeg, 2065; morig, 2067; and others of the range.
Curraun Achill, 1784 and 1715.
Achill, 2204 and 2192.
Croaghpatrick, 2510.
Mweelrea group; Delphi Mt. 2504 and 2474; Ben Gorm and Cregan, 2383 and 2283; and Mweelrea, 2688 and 2610.

In Mayo and Galway :—

Slieve Partry or Maamtrasna group; Devilsmother, 2131; M trasna (Formnamore), 2239 and 2209.

In Galway :—

Maamturk range; Leckavrea, 2012; Corcogemore, 2045; Maum 2076, &c.; Letterbrickaun, 2195; Maamturkmore, 2300; others of the chain.
Benchoona, 1975.
Bennabeola or Twelve Bens; Benbaun, 2395; Ben Lettery, 1904; kanaght, 2153, &c.

A short sketch of the botany of each of these groups will be g and finally a general view of the vertical range of plants throug the Mayo and Galway mountains. As heretofore, I refrain from paring these results with those obtained in other parts of Ireland the whole be completed.

neral features may first be noticed. Cultivation is rarely mountains at any considerable elevation. The highest the south-eastern slopes of Birreencorragh, north of 400 feet. Cultivated fields, grain, or tillage, scarcely 200 feet in the neighbourhood of the higher mountains. urite crop in the west of Mayo. Potatoes depend mainly ıson during the first part of July: upon this the pea- the success of their crop. There is little flax grown th Donegal, and wheat is rarely seen. The climate is hat of the east side of Ireland, and very much wetter. lief that, if reliable records were taken, the neigh- Delphi, at the base of Mweelrea and the upper part ord, would stand somewhere about the top of the list of ie kingdom. In consequence of this mildness, especially id the shelter from the severity of easterly winds, the parts of the west have a far richer flora than those on ide. On the other hand, several ranges in Galway are ren from their geological nature. The absence of "moun- " is prejudicial; and the prevalence of quartzite banishes from large areas. On this rock, and the scanty soil it y a few plants care to live. Of the mountain species, mes appear quite at home on quartzite, the following ioned :—

aritima.	Armeria maritima.
ı umbrosa.	Salix herbacea.
is.	Juniperus nana.
ria dioica.	Carex rigida.
phylos uva-ursi.	Lycopodium selago.
m nigrum.	L. alpinum

alpine species must be sought for off the quartzite, and k is flanked by schists, &c., the line of demarcation of the is, where they occur, rigorously defined.

ie above are confined to the quartzite; they grow as freely granite, or other siliceous rocks, and some of them on all ; but they may be regarded as almost its only alpine or ıabitants. As a rule, these mountains present wide sur- f all vegetation, the different species of heather appear- tches.

oaghpatrick and The Twelve Bens will be found de- ost interesting discoveries; a separate list of these will given. New localities were found for all the alpine ed from the mountains of Mayo and Galway (District 8 le Hibernica"), and several more were added to the list. lescend to an unexpectedly low level, especially in Gal- is little use in comparing these two counties, since the

mountains are almost continuous. The real difference lies nor south of Clew Bay. South of this bay, which is continuous wi levels inland, alpine species are more numerous and descend and this is still further the case south of the Killary in the Conn district. In one sense this is more an apparent than a real diff since the most universal species, *Salix herbacea* and *Carex rigi* scarcer in quantity southwards: the variety of kinds is, ho greater and wider-spread. *Carex rigida* descends to an unusual level at Nephin Beg—the lowest, I think, recorded. *Aira ca* var. *alpina*, was only met with on the Mayo mountains, or bordering chain.

Of those more thoroughly alpine plants which never desc sea level in these mountains (or elsewhere in Ireland), only th ever met with on the exposed summits or outer ridges; the *Salix herbacea, Carex rigida*, and *Lycopodium alpinum*. As soon ever, as the ground contours downwards towards any part horizon, except north or north-east, these disappear. On the no faces of cliffs these are, as a rule, confined to a higher zone than th alpine plants, especially *Lycopodium alpinum*, which rarely leav flatter summits and shoulders. Of those which do not descend nearly to, sea level, *Saxifraga oppositifolia* has the lowest range. C patrick, Maumeen, Ben Lettery, and Muckanaght, best illustr alpine flora of the Mayo and Galway mountains.

On Muckanaght, in The Twelve Bens, I found a Saxifrage is, as far as I can make out, indistinguishable from *S. cæspitosa* (Mr. Baker, who has kindly examined it, has, I am happy to say firmed my opinion. I have compared specimens with some b home from Greenland in 1876, and except for a more stunted h the northern plants, there appeared no difference.

S. cæspitosa (Linn.) has rested hitherto as an Irish plant the evidence of an imperfect specimen from Brandon, gathe 1829.[1] No form of *S. hypnoides* has been previously discove the Mayo or Galway mountains. Some plants at the lowe of its range on Muckanaght approach so closely to *S. platy* especially to the form on the Galtee mountains, that my was confirmed that these forms are inseparable to a degree of specific rank. Higher up on the cliffs the Muckanaght frage is fairly typical *S. cæspitosa*. Any stunted flowering of *S. affinis* or *S. hirta* which I have met with elsewhere in I have several leaves on the stem. The Connemara plant has one, or in rare instances, two. This is an important characte also separates and is distinctive of the larger and somewhat gling plant at the base of the mountain from *S. platypetala*. flowers in the Connemara plant are fewer, usually one to thre even in the larger forms nearly sessile; in *S. platypetala* th

[1] A. G. More—"Recent Additions to the Flora of Ireland."

pedicelled to half an inch or more. The leaves and sepals are much blunter than in any other Irish Saxifrages of the race, and the ovaries more distinctly semi-included in the calyx, which points to another character in the sepals being shorter: these latter are studded with gland-tipped hairs. The petals are also smaller in proportion to the sepals. The Connemara plant has not the weak trailing shoots of most of the *S. hypnoides* forms, and is, generally speaking, more distinct than any of them; widely so from the extreme plant *S. sponheimica*, which mainly differs from *S. hypnoides* in the absence of bulbs in the leaf axils.

In my Report on the Macgillicuddy's Reeks I have noticed the distribution of this race of plants upon some of the Kerry mountains, and on the Galtees in Tipperary. I have this year visited Ben Evenagh in Derry, and the Cummeragh and Knockmealdown mountains in Waterford. *S. sponheimica* (Gm.) is the plant which grows on these, its typical form occurring on the Derry basalt.

With regard to the Hieracia, to which I also paid particular attention, the following forms were gathered:—

Hieracium anglicum (Fr.)	H. vulgatum (Fr.)
H. iricum (Fr.)	H. gothicum (Fr.)

H. anglicum occurs frequently on the mountains as an alpine plant, and rarely at low levels in exposed rocky places. *H. iricum*, in its large, much-branched, very leafy form, is a plant of the glens and intermediate stations, never occurring in alpine situations. It passes into *H. anglicum* in intermediate stations, as above Doo Lough, opposite Delphi, and on Benchoona, in a series of doubtful plants; and having gathered a number of specimens throughout the two counties, I feel convinced that *H. iricum* is merely a luxuriant lowland form of *H. anglicum*. Typical *H. iricum* is rare in Ireland; it occurs in Galway at Kylemore and Benchoona. The Galtee form of *H. anglicum*, as well as that gathered on the Reeks, is intermediate, while the commonest hawkweed in mountainous districts of Donegal is typical *H. anglicum*.

H. vulgatum is scarce, and I only met with it on Muckanaght, where it passes insensibly into *H. gothicum*, which is, perhaps, the alpine form; it does not, however, occur with the alpine species. Typical *H. gothicum* is best seen at Maumeen, amongst the alpine plants. I met with neither of these in Kerry; but both occur, with intermediate forms, in Innishowen, Co. Donegal.

The vertical range of *Saxifraga umbrosa* calls for a note. In Kerry it descends from the highest summits to sea level or low levels inland constantly in the mountainous regions; in the Galtee, Cummeragh, and Knockmealdown mountains, it is thoroughly alpine in its general elevation, and though not dependent on aspect as alpine plants usually are, it never descends lower than 1700 or 1800 feet. In the Mayo and Galway mountains *Saxifraga umbrosa* occasionally

descends to sea level on the coast, usually ceasing at about 700
1000 feet and upwards. In Donegal it rarely descends lower th
about 2000 feet. Its general range is thus diametrically opposite
that of the alpine group, and is more properly classed with t
Atlantic or Western type.

Lest it should be thought that I have crowded in notes of heig
at random, I would ask leave to give the motives which usually guid
me in making the records. They are either to ascertain—

1. Upper and lower limits of alpine plants.
2. Upper limits of all species occurring on the mountains.
3. Unusually high or low elevation for any plants, outside th
apparent normal limits.
4. Notes on rare, local, or characteristic species.
5. Repeated observations on plants whose range will apparent
prove to be very constant, and, therefore, important to ascerta
accurately.

Having seen, moreover, how erroneous estimates of vertical rang
are, unless taken from a wide series of observations, I have slig
scruples in recording what may appear to be an excess. An addition
reason may be given in the obvious one that inaccuracies arising fro
a variable condition in the barometer, while observations are bei
made, will be reduced and equalized by considering the average
many records. By this means I have generally arrived at a very clo
approximation to the truth with regard to the altitude of certain lake
The upper limits of some mountain plants are as definitely fixed
the mountains themselves.

The mountainous district examined contained 227 species above th
elevation of 250 feet. A few of these are, however, merely varieties
The district is included in district 8 of the "Cybele Hibernica."

The following belong to Watson's Highland or alpine tpye:—

Thalictrum alpinum.
Sedum rhodiola.
Saxifraga stellaris.
S. cæspitosa.
S. oppositifolia.
Saussurea alpina.
Hieracium anglicum et H. iricum.
(H. gothicum.)
Arbutus uva-ursi.
Vaccinium vitis-idæa.
Oxyria reniformis.
Salix herbacea.
Juniperus nana.
Carex rigida.
Polystichum lonchitis.
Aira alpina.
Asplenium viride.
Lycopodium alpinum.
L. selaginoides.
Isoetes lacustris.

In addition to these, *Dryas octopetala*, *Galium boreale*, *Hieracium
crocatum*, and *Sesleria cœrulea*, are alpine plants occurring only at lo
levels elsewhere in District 8, as recorded in the "Cybele Hibernica.
In the above list *Saxifraga cæspitosa*, *Saussurea alpina*, *Aira alpina*
and *Polystichum lonchitis* are additions to the flora of this distric

'he whole is about two-thirds of the alpine flora of Ireland. Alpine arieties of *Armeria maritima*, *Alchemilla vulgaris*, *Plantago maritima*, '. *lanceolata*, and *Silene maritima* also occur.

The Scottish or northern group is well represented.

Thalictrum minus.
Subularia aquatica.
Drosera anglica.
Sagina subulata.
Rubus saxatilis.
Crepis paludosa.
Antennaria dioica.
Lobelia dortmanna.
Pinguicula vulgaris.
Empetrum nigrum.
Salix phylicifolia.
Listera cordata.
Habenaria albida.
Eriocaulon septangulare.
Carex limosa.
C. filiformis.

Several others occur in other parts of the district at low levels, as nay be seen in the "Cybele Hibernica." Of the above, *Salix phylicifolia* s an addition to the Flora of district 8. Somewhat more than half the otal number of the group occurring in Ireland are met with in the vest of Mayo and Galway.

Of Watson's Atlantic type, the following plants occur on the sides f the mountains, mostly at low levels:—

Meconopsis cambrica,
Sedum anglicum,
Cotyledon umbilicus,
Rubia peregrina,
Hypericum androsæmum,
H. elodes,
Pinguicula lusitanica,
Scirpus savii,
Lastrea æmula,
Adiantum capillus-veneris,
Hymenophyllum tunbridgense,
H. wilsoni,

nd several others along the coast.

Several other prevalent species in the west would advantageously e included in this group, to which their distribution in Ireland pparently refers them.

Since my general list is arranged with a view to exhibiting the ertical ranges, it is out of all systematic order, and it becomes difficult o refer to it for localities for the rarer species. I will therefore enunerate the rarest discoveries made, several of these being found in the owlands during my excursions from one chain to another. Those talicized are additions to the flora of District 8 of the "Cybele Hiberica" and to Mr. More's supplement.

Thalictrum alpinum (Linn.)—Croaghpatrick, Ben Choona, Maam Turk (Maumeen), Muckanaght and Ben Lettery. Recorded by Wade from Lettery, and by Dr. Moore from the "mountain above Kylemore castle," a hill which I omitted to visit.

T. minus (Linn.), var. montanum, (Wallr.)—Mweelrea, and Ben Choona. Chiefly known previously on the stony shores of the larger lakes.

Meconopsis cambrica (Vig.)—Muckanaght in Bennabeola. Found previously near Clifden.

Arabis hirsuta (R. Br.) Maumeen.—Rare in the west, except limestone.

‡Senebiera didyma (Pers.)—Achill sound at the ferry; a north-weste limit for this spreading species, which had not previously be known north of Galway on this side of Ireland.

Rubus saxatilis (Linn.)—Mweelrea, Croaghpatrick, and Bennabeo

Saxifraga cæspitosa (Linn.)—Muckanaght.

Saxifraga oppositifolia (Linn.)—Mweelrea and Muckanaght. Al on Maam Turk and Ben Lettery, which are given in the "Cybel and one locality I did not verify, "mountains in Joyce countr near Lough Corrib."

Ægopodium podagraria (Linn.)—Near Westport.

Œnanthe lachenalii (Gmel.)—Near Bundorragha on the Killar Known previously from one locality near Galway.

Œ. crocata (Linn.)—In several places about the Killary. Record only from Belmullet in the district.

Pastinaca sativa (Linn.)—Roadsides, and banks about Newport.

Rubia peregrina (Linn.)—Mweelrea and Salrock. Recorded pr viously from the shores of Lough Mask.

Saussurea alpina (Dl.)—Croaghpatrick, Ben Lettery, and Muckanagh

Hieracium anglicum and H. iricum (Fr.)—Mweelrea and Be Choona. H. anglicum is not unfrequent.

H. vulgatum (Fr.)—Muckanaght.

Arctostaphylos uva-ursi (Spr.)—Mweelrea, Nephin, and Nephinbe in Mayo. More frequent in Galway.

Vaccinum vitis-idæa (Linn.)—Only met with in very small quantit in one place on Mweelrea. Other localities are given in th "Cybele" which I failed to verify. It is very rare in th west.

Scrophularia aquatica (Linn.)—Bundorragha, at the foot of Mweelrea not seen elsewhere in the district except in the "Cybele" locality to the west of Galway.

Utricularia intermedia (Hayne.)—Frequent in the Mweelrea district at low levels, as well as about Connemara. This plant forms hybernacula, and if the fragile stem be lifted gently and traced through the mud with the fingers for the root, a little tuberous formation about the size of a bean will usually be found at the end of the stem. This habit is not mentioned in the British text-books, but Mr. Baker informs me that there are specimens exhibiting these hybernacula at Kew. I have seen undeveloped leaf-buds of U. vulgaris at the end of the summer, although not so dense; and Darwin says these "fall off and lie dormant during the winter at the bottom." In U. intermedia they remain attached, and form the point at which the arrested growth recommences the following season. Such a means of living is the more necessary to the present species, since it rarely seeds itself.

Statice bahusiensis (Frie.)—Shore below Croaghpatrick. Not found north of Clifden previously on the west side of Ireland.

Oxyria reniformis (Hook.)—On Loughty Mt. and Ben Gorm in the Mweelrea group, as well as on Mweelrea; not found on Ben Lettery, but grows on Muckanaght in Bennabeola; plentiful on Croaghpatrick.

Salix phylicifolia (Linn.)—By the stream out of Lake Lugaloughawn on Mweelrea. Mr. More agrees with me in this decision. A small, but handsome shrub with a distinct appearance, due to the somewhat shiny leaves, glaucous beneath, and rich-coloured twigs. Found in Ireland previously in two localities, one in Antrim and the other in Derry.

Salix herbacea (Linn.)—On all the higher mountains in both counties. Recorded only from Nephin and Nephinbeg.

Habenaria albida (Rich.)—Glen Laur. Also west of Galway and Lough Mask, "Cybele Hibernica."

Listera cordata (R. Br.)—Corcogemore. Recorded also from Slieve Cor.

Eriocaulon septangulare (With.)—Lakes west of Deel Bridge, between that and Corslieve. This extends the line marking its range on the map in the "Cybele Hibernica" northwards in Mayo to about the latitude of Crossmolina.

Sparganium natans (Linn.)—In a lake on the seaside of the road about half way between Newport and Molranny; in bog-holes about a mile south of Achill ferry on the mainland; at the foot of Croaghpatrick, on the inland side of the road by Clew Bay. In several places in Connemara.

S. minimum (Fr.)—Lake on Maamtrasna; Nambrackheagh lake on Buckoogh. Lake Lugaloughaun on Mweelrea.

Ruppia maritima (Linn.)—In a brackish pond near Newport.

Carex vulpina (Linn.)—With the last.

C. teretiuscula (Good)—By a lake about a mile from Newport on the roadside to Westport.

C. rigida (Good)—On all the higher Mayo mountains except Croaghpatrick. Only recorded from Nephin.

C. pallescens (Lam.)—Bennabeola, Mweelrea, and Delphi. It was perhaps this plant which Wade recorded as C. curta from Ben Lettery.

C. limosa (Linn.)—In a very wet bog at the foot of Nephin between Crampaun river and the road; southern side of Birreencorragh by some small lakes; bog-holes by the roadside between Ballinahinch lake and the canal bridge; bog-holes near Lough Fee to its east and between that and the Killary; at the base of Derryclare mountain by the shore of the lake.

C. filiformis (Linn).—In all the bogs with the last species, except the last-mentioned one. Also by the Erriff at the base of Ben Gorm. These two species occur in the very wettest shaky bogs in places which are usually considered unsafe to tread on. They have been recorded from only one or two localities in the west.

Lastræa oreopteris (Presl.)—Rather rare in the west. Letterbrick aun valley and Glencroff near the Killary.

Polystichum lonchitis (Roth.)—Muckanaght—only locality.

P. aculeatum (Roth.), Var. lobatum—Muckanaght and Maumeen.

Cystopteris fragilis (Bernh.)—Loughty Mt.; Muckanaght and Mau meen. Very rare.

Asplenium viride (Huds.)—Muckanaght; Croaghpatrick and Be Lettery. Only recorded from the last locality before.

Adiantum capillus-veneris (Linn.)—Achill (and Salrock?). Ver rare, but recorded from one or two localities previously.

Lycopodium clavatum (Linn.)—On the mountain opposite Leenan Hotel on the Killary. Appears to be very scarce, but I was no much on the lower grassy hills which this species affects.

L. alpinum (Linn.)—Mweelrea; Loughty Mt.; Curraun Achill, an Maam Turk. Recorded from the last locality and Ben Lettery where I did not observe it.

Before proceeding to my detailed account of the mountain range I take this opportunity of expressing my thanks to Professor Babing ton of Cambridge, Mr. Baker of Kew, and Mr. More of Dublin, wh have kindly examined and given their opinion upon rarer and critic species.

In my survey of each mountain, I suppose the reader to start fro the summit and descend downwards in various directions.

Nephin is an isolated, rounded lump of quartzite, rising to 264 feet above sea level. It is second in height to Mweelrea in Mayo the highest in the west of Ireland, and situate north-west of Newpo on Clew Bay. The barren nature of the rock of which it is formed and the even shape of its surface, render it obviously uninterestin botanically. Nevertheless it appears to be the only point in the wes which has received much attention from botanists, and these reason combined with a steady downpour of rain, caused me to be satisfie with a rather hurried survey. Dr. Dickie has given a slight account o its plants in his "Flora of Ulster." He records *Carex rigida* from th summit, 140 feet higher than I observed it, and three common specie which I noticed on the top do not appear in his list. There is, how ever, a stranger disagreement between us. *Arctostaphylos uva-ursi* i very abundant south from the summit in the direction of Crampton Wood. It appears, as we descend, at about 1650 feet; is very abun dant at 1500, and disappears at about 1240. Neither Dr. Dickie no Professor Babington observed this species, although both have recorded *Vaccinium vitis-idæa* from Nephin, which I did not meet with. The former does not, however, include it in the list of Nephin plants given in his Introduction. *Vaccinium vitis-idæa* appeared to me extremely rare in Mayo and Galway; at least, on the higher mountains. Dr. Dickie does not mention *Antennaria dioica*, *Hieracium anglicum*, *Salix herbacea*, *Silene maritima*, or *Saxifraga stellaris*, which I met with at considerable heights.

On the north-eastern side of the northern spur of Nephin, the rock

s more schistose in its nature, and on some slight prominences in a teep and rapidly degrading declivity, a few alpine plants occur. Iere, as on Croaghpatrick in a less striking manner, one cannot fail o be impressed with the idea how insecurely established these slight atches of rarer plants on a continually wearing surface must be; how aany may have disappeared, or are gradually disappearing, except on hose mountain ranges where solid ranges of cliffs occur. This rumbling schistose rock is, in Mayo and Galway, the chief home of he alpine plants, overlying the prevalent quartzite formation in deached positions, and forming a rich and suitable soil by its rapid disntegration. Its scattered and infrequent occurrence, as well as its nstable nature, may, in some degree, account for the unsatisfactory, asual distribution of the alpine flora.

At the base of Nephin, on the south-western side, there is a coniderable patch remaining of an ancient forest. During my visit to his part of Mayo I lodged with a kindly and respectable "strong" armer named Daly, who has lived here for seventy years, and whose orefathers held the ground before him. He remembers when, instead f a strip a couple of miles long, there were many square miles of orest, which, in his father's time, clothed the long valley northward owards Deal Bridge; when the bitterns, "like bulls," answered one nother over the moors. He had seen ruffs here in his youth, a pair f which had been shot about forty years ago, and the *mad-ye-'cran* pine-marten) was then frequent in the forest. There was also "a vild cat which dogs that would face a fox would not cope with." I vas specially interested in his account of squirrels having formerly een frequent in these native woods, which, if true, would surely stablish its claim to being an indigenous inhabitant animal of Ireland. Iy informant was very intelligent and apparently, as well as by reputtion, quite trustworthy. At the mention of squirrels, I asked him to escribe them, which he did, and their "drays," as he had seen them n these woods, quite correctly. He says they are still there in much iminished numbers, living, as of old, on the nuts which abound there. 'hese remarks may savour to some more of romance than of scienific research, and must, no doubt, be received with caution; but the uestion whether the squirrel is indigenous or not in Ireland has been he subject of much careful investigation by my friend Mr. Barrington, vho has, in an able Paper on the subject, decided against it. The bove clue, if worked out, may throw new light on the question.

The mention of the forest led me to the above digression. I exmined these woods carefully, and found the following trees to be ndigenous:—ash, oak, birch, mountain ash, alder, sallow (*Salix capræa*), azel, and blackthorn. Some of the alders are remarkably well grown -forty to fifty feet high—with a trunk over a foot in diameter; the sh trees are of medium size; the oaks old, but badly developed.

The alpine plants I observed on Nephin were—*Saxifraga stellaris*, *Hieracium anglicum*, *Arctostaphylos uva-ursi*, *Salix herbacea* and

Carex rigida. *Saxifraga umbrosa* is abundant from the base to the summit.

NEPHIN SUMMIT.

2640 feet.

Potentilla tormentilla.	Rumex acetosa.
Saxifraga umbrosa.	Luzula sylvatica.
Galium saxatile.	Anthoxanthum odoratum.
Calluna vulgaris.	Aira flexuosa.
Vaccinium myrtillus.	Festuca ovina.
Empetrum nigrum.	Asplenium dilatatum.
Armeria maritima.	Lycopodium selago.

NORTH-EAST SLOPE.

2500 feet.

Carex rigida.

2450 feet.

Saxifraga stellaris.	Salix herbacea.

NORTH-WEST SLOPE.

2300 feet.

Melampyrum montanum.

SOUTH SPUR.

1830 feet.

Salix herbacea (lower limit).	Antennaria dioica.

1870 feet.

Silene maritima.

1750 feet.

Erica cinerea.

1660 feet.

Arctostaphylos uva-ursi.

1490 feet.

Hieracium anglicum.

WESTERN SLOPE.

1290 feet.

Solidago virgaurea.	Erica tetralix (upper limit)

Hymenophyllum unilaterale.

WESTERN SLOPE—*continued.*

1240 feet.

Antennaria dioica, Lycopodium selago } Scarce.	Arctostaphylos uva-ursi (lower limit).

1000 feet.

Empetrum nigrum (lower limit).

700 feet.

Comarum palustre.	Lychnis flos-cuculi.

500 feet.

Cratdegus oxyacantha.	Drosera anglica.

D. rotundifolia.

250 feet.

Sanicula europæa.	Lastrœa œmula.
Ilex aquifolium.	Osmunda regalis.

In Crampaum woods few plants of interest were observed, the trees ave been already mentioned. Along the mountain's western base were oted *Bidens cernua, Crepis paludosa, Pinguicula lusitanica, Hypericum ndrosæmum, Scirpus setaceus, S. savii, Habenaria chlorantha, H. ifolia, Plantago maritima* (low inland level), *Festuca sciuroides, Carex ulicaris, C. sylvatica,* and other commoner sedges; while to the est of the road, in a very wet bog between it and Crampaun river, observed *Utricularia minor, U. intermedia, Drosera intermedia, Allium rsinum* (by the river), *Schœnus nigricans, Rhynchospora alba, Carex aniculata, C. ovalis, C. limosa,* and *C. filiformis.* These two last rare ecies I have several times noted together in the wettest spongy gs in Mayo and Galway.

A few miles westward of Nephin, across the valley of the Cram-un river, lies a cluster of mountains around the head of the Skirdagh er, of which the highest are Birreencorragh, 2295 feet, and Buck-gh, 1900 feet above Lough Feeagh, which is almost an estuary m Clew Bay. These are uninteresting mountains, devoid of cliffs, d unsuitable for genuine alpine plants, none of which were met th. A series of notes on the upper ranges of lowland species was de, however, and a few interesting mountain plants are recorded. the south-eastern slopes of Birreencorragh there are cultivated lds to about 400 feet; the highest I met with in the west.

BIRREENCORRAGH, SOUTH SIDE.

2000 feet.

Silene maritima.	Armeria maritima.

BIRREENCORRAGH, SOUTH SIDE—*continued.*

1500 feet.

Erica cinerea (appears).

1200 feet.

Erica tetralix (appears).

1150 feet.

Antennaria dioica.
Narthecium ossifragum
Lycopodium selago.

HEAD OF THE SKIRDAGH RIVER.

1100 feet.

Linum catharticum.
Bellis perennis.
Carduus pratensis.
Prunella vulgaris.
Holcus lanatus.

900 feet.

Carex fulva.

775 feet.

Alchemilla arvensis.
Myrica gale.

600 feet.

Eleocharis multicaulis.
Pteris aquilina (appea

SOUTH-EASTERN SLOPES, TOWARDS DERRYROE BRIDGE.

380 feet.

Anthemis chamomilla.
Agrostis pumila.

350 feet.

Nymphœa alba.
Hypericum elodes.
Lobelia dortmanna.
Utricularia intermedia.
Menyanthes trifoliata.
Eriocaulon septangula
Scirpus fluitans.
Rhynchospora alba.
Carex limosa.
C. filiformis.

BUCKOOGH.

1920 feet.

First six of Nephin, and
Solidago virgaurea.
Pinguicula vulgaris.
Luzula sylvatica.
L. campestris.
Juncus squarrosus.
J. effusus.
Eriophorum polystach
Scirpus cæspitosus.
Festuca ovina.
Aira flexuosa.

EAST SIDE.

1880 feet.

Scabiosa succisa.

1680 feet.

Oxalis acetosella.

LAKE NAMBRACKKEAGH.

1180 feet.

Trifolium repens.	Salix aurita.
Lysimachia nemorum.	Potamogeton natans.
Lobelia dortmanna.	Sparganium minimum.
Litorella lacustris.	Carex vulgaris.

Isoetes lacustris.

To the west of this cluster of mountains a long valley runs north om Lough Feeagh, along the eastern flanks of the Nephinbeg range, till meets the great moorland west of Crossmolina, through which the Deel ver runs. About ten miles north of Lough Feeagh, near Deel Bridge, ere is a multitude of small lakes on this wet moor, in which I found *riocaulon septangulare*, a station somewhat north of the line marking range in Mayo, as given in the "Cybele Hibernica." Mamm-y-Kelly, 05 feet, rises from this moorland, and forms the northern extremity the Corslieve range, which is continuous in direction, and forms one ith the Nephinbeg range. They are, however, severed by a low lley, 750 feet, between Corslieve and Nephinbeg, and there is a still wer one between Nephinbeg and Glenamorig. The whole chain ns about fifteen miles southwards to the waters of Clew Bay. Much it is over 2000 feet above sea level, and it rises to nearly 2400 feet two or three points. These mountains are chiefly quartzite, of the rrenest description, and contain a poor flora. *Salix herbacea* and *rex rigida*, two of the few plants which thrive on this formation, , however, very abundant. These and *Arctostaphylos uva-ursi* re the only Alpines met with; the occurrence of *Carex rigida* at so w a level as 860 feet is very remarkable. I walked this range from rth to south, leaving my car about two miles north of Deel Bridge, d finishing the same night at Newport. This was intended to be a eparatory exploration; but these mountains appeared utterly un- rthy of a second botanical visit. They are wild and grand and gged enough, with many a bit of lovely scenery, as about Scardaun ke; but one gets to know the capabilities of mountains for contain- varieties, and the few likely places at sufficient altitude were rched with very slight success. The highest point of the Corslieve up is called "Laghtdauhybaun" on the map. I did not hear this aw-breaker" used in the country, and I may be excused if I call it Corslieve.

CORSLIEVE, DOWN TO NORTH-EAST.

2320 feet.

Saxifraga umbrosa.	Salix herbacea.

Carex rigida.

2250 feet.

Melampyrum montanum.	Empetrum nigrum

2025 feet.

Carex rigida.	C. pilulifera.

C. binervis.

1750 feet.

Hymenophyllum unilaterale.

1700 feet.

Pyrus aucuparia.

LAKE DRUMDERG.

1330 feet.

Saxifraga umbrosa.	Isoetes lacustris.

600 feet.

Epilobium obscurum.	Pinguicula lusitan

Equisetum sylvaticum.

WET MOOR at 250 feet.

Lychnis flos-cuculi (white).	Eriocaulon septan
Lobelia dortmanna.	Rhynchospora alb
Utricularia minor.	Eleocharis multic

DOWN SOUTH TOWARDS SCARDAUN LAKE.

2000 feet.

Saxifraga stellaris.	Oxalis acetosella.

Carex rigida.

1700 feet.

Crepis paludosa.

1600 feet.

Sedum rhodiola.

1400 feet.

Saxifraga stellaris.

Scardaun Lake, N.-E. Corner.

860 feet.

elia dortmanna.	**Narthecium ossifraga.**
pseudacorus.	**Carex rigida (lower limit).**

Isoetes lacustris.

Nephinbeg.

2060 to 1900 feet.

Carex rigida.

South Side.

1425 feet.

Erica cinerea.

1325 feet.

Holcus lanatus.

850 feet.

Eleocharis multicaulis.

Glanamorig, down N.-W.

2100 feet.

t herbacea.	**Carex rigida.**

1750 feet.

Narthecium ossifragum.

1700 feet.

Salix herbacea (lower limit).

1600 feet.

Carex rigida (lower limit).

400 feet.

Hymenophyllum tunbridgense.

325 feet.

nnaria dioica.	Arctostaphylos uva-ursi.

Ridge South of Glenamorig.

2300 to 1750 feet.

Carex rigida (abundant).

2200 feet.

Poa annua.

Westwards of this chain of mountains the land subsides to l
levels along Blacksod Bay and Bellacragher (Ballycroy) Bay.
latter winding, narrow estuary, runs down from the northwar
within an English mile of Clew Bay on the south. This penin
about six or seven miles in diameter, is called Curraun Achill, a
separated by the narrow strait of Achill Sound from Achill Is
Curraun Achill is known to botanists as being the head-quarters o
Mediterranean heath in Ireland. It is all mountainous: consisti
a detached peak (1500 feet) in the northern part, which I di
examine, and a wide table-land at about 1300 feet, rising in plac
1700 feet, above sea level, which includes the chief southern p
the promontory. This table-land is composed of quartzite, and s
quently of horizontally stratified sandstones and conglomerates, w
break away into regular terraces along its north-eastern edge
picturesque and unusual character. This sandstone is, I be
lower carboniferous; it soon, however, gives place to the perp
quartzite forming the greater part of Curraun. On the table-la
1200 feet, Arctostaphylos, Empetrum, and Juniper form a c
the first and last being remarkably abundant. At a greater h
Salix herbacea and *Carex rigida* were, as usual, met with, and
these a rarer alpine species, *Lycopodium alpinum*, which was
seen in two or three places in the west.

CURRAUN ACHILL, DOWN NORTH-EAST.

1560 feet.

Salix herbacea.	Carex flava.

Lycopodium alpinum.

1200 feet.

Lotus corniculatus.	Plantago maritima.
Arctostaphylos uva-ursi.	Empetrum nigrum.
Armeria maritima.	Juniperus nana.

200 feet.

Hymenophyllum tunbridgense.	H. unilaterale.

150 feet.

Erica mediterranea.

SOUTH OF FERRY, NEAR SEA LEVEL.

Sparganium natans.	Rhynchospora alba.

The Island of Achill is shaped somewhat as a right-angled triang
the shorter sides running due north and south, east and west. Fr

e north-east corner it is about fifteen miles to Achill Head, the estern extremity, and about the same distance along Achill Sound to chill Beg Island on the extreme south. The base line from north-est to south-east is curved far inwards, and the whole coast line oroughly "nook-shotten." The ferry by which the island is reached s about the middle of the eastern side of the island. It is hardly a one's throw across, and fordable at low water. From this point to e missionary settlement on the northern coast of the island is about n miles, where comfortable quarters are available at Mr. Sheridan's tel, whose enthusiastic love for natural history, and ability and wil-igness to act as guide, add to the interest of a visit. The settlement situated at the eastern base of Slieve More, 2204 feet, the highest int of Achill. This mountain slopes gradually to the sea. Soon, wever, the coast line rises again, becoming more and more precipi-us, till it finally culminates in the noble range of cliffs at Croghaun, 92 feet, about five miles west of Slieve More. A day along these gher parts of Achill gave the undermentioned results. The forma-n is quartzite chiefly, and the flora appears uninteresting. I searched veral likely places for the more remarkable west of Ireland plants; t, with the exception of London Pride and Maiden Hair fern, none re met with. The discovery of the latter is not due to me; but it s not, I think, been previously recorded. As I had expected, the pine sedge and willow, so prevalent in the west, occur at suitable ights on the quartzite of Achill.

SLIEVE MORE (DOWN EAST AND NORTH-EAST).

2200 feet.

Oxalis acetosella.	Armeria maritima.
Vaccinium myrtillus.	Empetrum nigrum.

Plantago maritima, &c.

2080 feet.

Saxifraga stellaris.

2030 feet (and upwards).

Salix herbacea	Carex rigida

1730 feet.

Saxifraga umbrosa (and upwards).	Solidago virgaurea.
	Luzula sylvatica.
Melampyrum pratense.	Carex flava.

Hymenophyllum unilaterale.

1430 feet.

Pyrus aucuparia.	Hieracium anglicum.
Sedum rhodiola.	Asplenium trichomanes.

Hymenophyllum tunbridgense.

AT OR NEAR SEA LEVEL.

Sedum rhodiola.	Empetrum nigrum.
Samolus valerandi.	Salix repens.
Pinguicula vulgaris.	Scirpus savii.
P. lusitanica.	Kœleria cristata.

CROGHAUN.

1900 feet.

Oxalis acetosella.	Lastrœa dilatata.
Salix herbacea.	Hymenophyllum wils

NORTH FACE.

1825 feet.

Saxifraga stellaris.	Carex rigida.

EAST SIDE.

1480 feet.

Polygala depressa.	Narthecium ossifragu
Pinguicula vulgaris.	Juncus effusus.

SOUTH SIDE.

1300 feet.

Arctostaphylos uva-ursi. }
Juniperus nana. } Scarce.

EAST SIDE.

800 feet.

Pinguicula lusitanica.

800 feet.

Sedum anglicum.

NEAR SEA LEVEL.

Adiantum capillus-veneris.

At the ferry at Achill I observed *Senebiera didyma*—the northern point it seems to have spread to on the west of Ir Near Newport, by the roadsides and elsewhere, were observed *torium cannabinum*, *Pastinaca sativa*, *Carex teretiuscula*, and *glaucus*; and in a brackish pond, *Carex vulpina* and *Ruppia ma* None of these last, except Eupatorium, which appeared to m rare in the western mountainous districts, are recorded in the " Hibernica" from District 8. Between Newport and Mulraney

Apium graveolens, Bidens cernua, B. tripartita, Scirpus tabernæmontani, and *Sparganium natans,* the latter being especially plentiful in a pond about half way on the seaward side of the road. A willow, apparently *Salix purpurea,* in wet hedges along the roadside between Newport and Westport, may be worth examining when in flower, but it is probably planted.

The mountains of Mayo considered so far lie to the north of Clew Bay. I shall now describe the vegetation of those situated in the outhern part of the county. There is a considerable increase in the ariety of species to be met with both of lowland and mountain plants, s compared with the barren district we are leaving behind. There is lso, fortunately, a considerable increase in the accommodation to be net with; and, although there are no more maritime cliffs akin in randeur to those of Achill, there is far more loveliness of lake and nountain scenery, ever increasing as we travel south to Connemara. The most conspicuous feature on the southern side of Clew Bay, perhaps in the whole west of Ireland, is Croaghpatrick, 2510 feet. This nountain is easy of access from Westport, there being, I believe, a bridle-path to the summit; and I had almost concluded, since no plants of interest have been accredited to it, that it had been long known to contain none, the more so since it appeared to be composed of the inevitable and inhospitable quartzite. The "Cybele Hibernica" has but two records from Croaghpatrick, *Silene maritima* and *Armeria maritima,* both unimportant. These are due to Dr. Patrick Browne. The mountain has therefore been botanized; and, since it is the Irish ocality for the only Irish alpine butterfly, *Erebia cassiopeia,* as I am nformed by Mr. More, it has by no means escaped the attention of aturalists. Fortunately, however, I determined to try for myself, nd a fine northern face of precipitous declivities looked and proved to worthy of a botanist's attention. Before describing the flora of roaghpatrick, I must say one word for the view from the summit. does not equal in grandeur that from Carran Tuohill, or in rugged ldness that from Slieve Snacht West in Donegal; but, as I think, no her point in Ireland, with its wide and varied prospect of lake and ountain, island and ocean, gives a scene of such surpassing loveliness Croaghpatrick.

"The Reek," as this mountain was formerly called, sloping gradually to the water's edge as it does, is well suited for noticing the rtical range of plants. Greater accuracy with the aneroid was perps here arrived at than in the previous ranges, so that a more pious series of observations will be recorded. These were chiefly ken on the northern face, and on this face an interesting assemblage alpine plants was discovered. These were: *Oxyria reniformis, Saussrea alpina, Thalictrum alpinum, Asplenium viride,* and *Salix herbacea,* well as other commoner ones, all in plentiful quantity. *Saussurea lpina* has not been previously gathered in Mayo or Galway. *Thalicum alpinum* and *Asplenium viride* only in a single locality each. *Carex igida,* as is sometimes the case, is supplanted here by *Carex flava.*

The rock, or rather shingle, amongst which these plants gro[w] rapidly disintegrating schistose rock. The slopes are very ste[ep] of insecure footing, but with a little care all these plants may be viewed, and the risk is rather that of a slide upon gravel than amongst cliffs.

CROAGHPATRICK.

Summit, 2510 feet.

The first twelve of NEPHIN and Rumex acetosella

Juncus squarrosus.	Poa annua.

DOWN SOUTH-EAST.

2350 feet.

Carex binervis.

1850 feet.

Eriophorum vaginatum.

1740 feet.

Juniperus nana.	Lycopodium selago.

1690 feet.

Erica cinerea (begins).

1670 feet.

Antennaria dioica.

DOWN NORTH.

1900 feet.

Viola sylvatica.	Jasione montana.

Melampyrum pratense.

1850 feet.

UPPER LIMIT OF ALPINE PLANTS.

Salix herbacea.	C. pilulifera.
Carex flava.	C. binervis.

1800 feet.

Asplenium viride.

1740 feet.

Sedum rhodiola.	Oxyria reniformis.
Hedera helix.	Blechnum boreale.
Euphrasia officinalis.	Asplenium viride.

Polypodium vulgare.

CROAGHPATRICK—*continued.*

1650 feet.

Cardamine hirsuta.
Sagina procumbens.
Rubus saxatilis.
Scabiosa succisa.
Taraxacum dens leonis.
Hieracium anglicum.
Primula vulgaris.
Carex panicea.
Lastrœa dilatata.

1630 feet.

Senecio jacobœa.
Hieracium anglicum.
Rhinanthus crista-galli.
Plantago lanceolata.
Lastrœa filix-mas (var. abbreviata).

1590 feet to 1570 feet.

Ranunculus repens.
Thalictrum alpinum.
Viola sylvatica.
Polygala vulgaris.
Oxalis acetosella.
Sedum rhodiola.
Angelica sylvestris.
Saussurea alpina (lower limit).
Crepis paludosa.
Taraxacum densleonis.
Campanula rotundifolia.
Oxyria reniformis (lower limit).
Primula vulgaris.
Pinguicula vulgaris.
Thymus serpyllum.
Euphrasia officinalis.
Salix herbacea (lower limit).
Carex flava.
Eriophorum polystachyon.
E. vaginatum.
Asplenium trichomanes.
A. viride (lower limit).

1560 feet.

Erica cinerea (begins).

1390 feet.

Dabæocia polifolia.

1370 feet.

Ranunculus flammula.
Cardamine pratensis.
Viola palustris.
Trifolium repens.
Stellaria uliginosa.
Cerastium triviale.
Myosotis repens.
Callitriche platycarpa.

1300 feet.

Pteris aquilina.

1280 feet.

Digitalis purpurea.
Orchis maculata.

1170 feet.

Erica tetralix.

CROAGHPATRICK—*continued.*

1000 feet.

Solidago virgaurea.	Empetrum nigrum (lower limit).

820 feet.

Carduus palustris.	Anagallis tenella.

630 feet.

Cotyledon umbilicus.	Scilla nutans.
Pyrus aucuparia.	Lastræa æmula.

300 feet.

Ulex europaeus.

250 feet (Cultivation begins).

At sea level, at the base of Croaghpatrick, I noticed on the south side of the road in deep ditches by a pond *Alisma ranunculoides*, *Sparganium natans*, and *Carex paniculata*; and on the shore at the north side of the road, *Kœleria cristata*, *Carex extensa*, *C. distans*, and *Statice bahusiensis*, with commoner species. Stàtice has not been found north of Clifden on the west coast previously. On the way to Westport I noticed *Œgopodium podagraria*, not before recorded from western Mayo or Galway.

From the summit of Croaghpatrick, the most prominent group of mountains in view is that of Mweelrea, about eight or ten miles distant in a south-westerly direction. Mweelrea, 2688 feet, is the highest summit in the west of Ireland, north of Brandon. Seen at a distance it appears to be continuous with the rest of the mountain land around Doo Lough, and these high table-lands, north of Killary fiord at the south-west corner of Mayo, will be best considered as one mass divided into three distinct portions by low-lying river valleys. These mountains are composed of Silurian slates chiefly with sandstones, schists, and conglomerates, and we no longer meet with the dome-shaped or conical summits usual to the quartzite formation. At Cead-na-binnian there is a considerable exposure of gneiss. Plateaus bounded by long ranges of precipices, ridges, and gullies, ending in ravines with sheer sides and dangerous nooks and corners, promised well for alpine botany. Amongst these I climbed every day for a week in constant expectation, but I met with no such variety as I had hoped: there were, however, some interesting discoveries made.

Taking the southern end of Doo Lough as the centre, the three valleys dividing the mountains radiate at about equal angles from this point. Of these, one, that of Delphi, Fin Lough, and Bundorragha

er, runs a little west of south to Killary fiord; while a second, that Glenummera river, Tawnyard Lough, and Owenduff river, runs t to the Erriff. Between these two valleys and that of the Erriff the south, none of which are more than 200 feet above sea level, a triangular tract of land rising gradually westwards to table-ds, and ridges about 2300 feet. These have no name on the Ordi-nce Map, and other sources gave me choice of Ben Cregan, ad-na-binnian, or Ben Gorm, to stand for the mass. The third ley is that of Doo Lough, Lough Cullin, and Lough Connel, nning north-west, and leading us by low levels to the sea. Be-een it and the Glenummera, or rather to the north of these valleys a mountainous tract, reaching a height of over 2400 feet in several nts and ridges, and cut into by valleys, of which the chief is that of Glen Laur river; the highest point lies above Doo Lough, and is ed by the natives Delphi mountain, while running east from it is a g elevated spur, called Loughty mountain, ending in the Glen Laur ey. As before, the inch Ordinance Map gives no name for these intains. To the west of Doo Lough valley, and enclosed by it, lary fiord and the Atlantic, lies Mweelrea fronting the mouth of fiord and curving in a grand tabular ridge, 2600 feet high, to the th, above two tarns in a coomb at 1200 feet. This ridge bounds ng valley, that of the Owenaglogh river, with an eastward sweep it terminates in abrupt declivities above Lough Doo and in the ck, barren, sunless precipices and gorges of Ascokeerin, around the d of Glencullin. These latter I climbed from base to summit, l of hope, 2000 feet of cliffs, but they yielded no rarities.

In average weather the scenery here is delightful, and there is ch to interest the lover of nature. At the mouth of the Killary I v a pair of golden eagles upon two occasions, and choughs, ravens, l peregrines, all were met with. The pass of Delphi and Doo Lough, ied in the mountains, are the most imposing scenes of wild gran-ur in the west.

I spent a week amongst these mountains, chiefly at higher levels, which I made a careful examination. One or two of the lakes at low els, and the Atlantic coast line, I did not explore, these being newhat outside my subject. I endeavoured here, however, as in rry last year, to obtain a knowledge of the lowland flora of the nediate neighbourhood with a view to seeing what species are ble to ascend the slopes; and what mountain plants can, in so pting a situation, descend to sea level. I will first give an account he northern section of the Mweelrea mountain group, starting as al with the highest point. The commoner species are not repeated, will be enumerated under the highest summit of all, Mweelrea. alpine species occurring are, *Oxyria reniformis*, *Saxifraga stellaris*, *oppositifolia*, *Vaccinium vitis-idæa*, *Lycopodium alpinum*, *Salix bacea* and *Carex rigida*, the last three and *Saxifraga stellaris* alone ng frequent. The other three occur, together with *Cystopteris fragi-* very sparingly in one place only.

DELPHI MT., NEAR SUMMIT.

2550 feet.

Achillea millefolium.
Plantago maritima (var. alpina).
P. lanceolata.

DOWN WEST.

2000 feet.

Equisetum palustre.

DOWN SOUTH-WEST, ABOVE LOUGH DOO.

1600 feet.

Dabeocia polifolia.

1550 feet.

Rosa pimpinelloides.
Lonicera periclymenum.
Salix aurita.
Juniperus communis.

1500 feet.

Betula alba.

800 feet.

Pteris aquilina.

600 feet.

Ilex aquifolium.

400 feet.

Carex pallescens.

LOUGHTY MT.

(Ridge above Lough Bawn).

Cliff 2458 feet.

Lycopodium alpinum.

2400 feet.

Geum rivale.
Saxifraga oppositifolia.
Antennaria dioica.
Vaccinium vitis-idæa.
Oxyria reniformis.
Salix herbacea.
Cystopteris fragilis.

LOUGHTY MT.—*continued.*

2350 feet.

Achillea millefolium.	**Plantago maritima (var. alpina).**
Leontodon autumnalis.	**Eriophorum** polystachyon.
Armeria maritima.	

DOWN TO GLEN LAUR.

1750 and 1630 feet.

Dabeocia polifolia (appears.)

1050 feet.

Saxifraga stellaris.	**Montia fontana.**

770 feet.

Erica tetralix (appears.)	**Myrica gale** (appears.)

630 feet.

Epilobium palustre.	**Betula alba.**
Pyrus aucuparia.	**Salix aurita.**

500 feet.

Cratægus oxyacantha.

BY GLEN LAUR RIVER, NEAR SHEFFRY.

250 feet.

Rosa tomentosa.	Habenaria chlorantha.
Stachys palustris.	Ceterach officinarum.

LOWER DOWN, TO ERRIFF MEETING.

Thalictrum minus (var. flexuosum).	Crepis paludosa.
Sarothamnus scoparius.	Plantago maritima (inland locality).
Œnanthe crocata.	Utricularia intermedia.
Viburnum opulus.	Habenaria albida.

LOUGHTY MT., DOWN SOUTH TO GLENUMMERA.

2050 feet.

Empetrum nigrum.	Cerastium triviale.

1250 feet.

Bellis perennis.

LOUGHTY MT. DOWN SOUTH TO GLENUMMERA—*continued.*

500 and 400 feet.

Carex fulva.	C. œderi.

RIDGE BETWEEN GLENUMMERA AND ERRIFF.

1000 feet.

Orchis latifolia.	Carex fulva.

Crossing the Glenummera river we come to Ben Cregan a Gorm.

The alpine species met with are: *Oxyria reniformis, Salix h* and *Carex rigida.*

BEN GORM TABLE-LAND

(Down north and west towards Delphi).

2200 feet.

Potentilla tormentilla.	Juncus squarrosus.
Saxifraga umbrosa.	Ereophorum vaginatu
Galium saxatile.	Carex pilulifera.
Jasione montana.	Nardus stricta.
Calluna vulgaris.	Agrostis vulgaris.
Vaccinium myrtillus.	Aira alpina.
Thymus serpyllum.	Festuca ovina.
Luzula campestris.	

2150 feet.

Viola sylvatica.	C. rigida.
Salix herbacea.	Blechnum boreale.
Carex pilulifera.	

2100 feet.

Campanula rotundifolia.	Antennaria dioica.

1940 feet.

Pinguicula vulgaris.	Orchis maculata.

1850 feet.

Oxalis acetosella.	Hymenophyllum uni
Asplenium dilatatum.	

1550 feet.

Plantago maritima.

BEN GORM TABLE-LAND—*continued.*

1200 feet.

Digitalis purpurea.

750 feet.

Pteris aquilina.

200 feet.

Myrica gale.	Carex fulva.

DOWN SOUTH TO KILLARY.

2050 feet.

Erica cinerea.	C. flava.
Pinguicula vulgaris.	Aira flexuosa.
Narthecium ossifragum.	A. cœspitosa.
Eriophorum polystachyon.	Lycopodium selago.
Carex panicea.	

2030 feet.

Viola palustris.	Scirpus cæspitosus.

1900 feet:

Lycopodium clavatum.

1850 feet.

Salix herbacea.

1600 feet.

Luzula campestris.

1350 feet.

Dabeocia polifolia.

1100 feet.

Drosera rotundifolia.	Schœnus nigricans.

800 feet.

Anagallis tenella.

DOWN EAST TO ASHLEACH BRIDGE.

2030 feet.

Armeria maritima.	Carex rigida.
Oxyria reniformis.	Hymenophyllum unilaterale.

Down East to Ashleagh Bridge—*continued.*

1880 feet.

Empetrum nigrum.	Salix herbacea.

800 feet.

Erica tetralix.

Wet Bog by Erriff River.

Carex filiformis.

We will next examine Mweelrea, not only the highest mount in Connaught, but with much the most considerable extent of elevat ground. The alpine species are: *Saxifraga stellaris, Sedum rhodi Hieracium anglicum, H. iricum, Arctostaphylos uva-ursi, Oxyria re formis, Salix herbacea, Carex rigida, Aira alpina, Lycopodium alpin L. selaginoides, Isoetes lacustris.*

Mweelrea Summit.

2680 feet.

Potentilla tormentilla.	C. binervis.
Saxifraga umbrosa.	Scirpus cæspitosus.
Calluna vulgaris.	Luzula sylvatica.
Vaccinium myrtillus.	L. campestris.
Thymus serpyllum.	Juncus squarrosus.
Rumex acetosa.	Nardus stricta.
R. acetosella.	Anthoxanthum odoratum.
Eriophorum vaginatum.	Agrostis vulgaris.
Carex pilulifera.	Aira cæspitosa.

Festuca ovina.

2640 feet.

Armeria maritima.

2600 feet.

Campanula rotundifolia.	Plantago maritima.
Solidago virgaurea.	Salix herbacea.
Melampyrum pratense.	Carex rigida.

Aira flexuosa.

East and South-east to Bundorragha.

2590 feet.

Hymenophyllum unilaterale.

2440 feet.

Salix herbacea.

EAST AND SOUTH-EAST TO BUNDORRAGHA—*continued.*

2380 feet.

Lastrea filix-mas.	L. dilatata.

Polypodium vulgare.

2250 feet.

Blechnum boreale.

2000 feet.

Hypericum pulchrum.	Pedicularis sylvatica.

1900 feet.

Ranunculus ficaria.	Digitalis purpurea.
Stellaria uliginosa.	Primula vulgaris.

Poa annua.

1850 feet.

Vicia sepium.	Epilobium palustre.

Lysimachia nemorum.

1600 feet.

Asplenium trichomanes.

1520 feet.

Thalictrum minus.	Hieracium anglicum.
Lathyrus macrorrhizus.	Plantago lanceolata.

1500 feet.

Stellaria uliginosa.	Epilobium montanum.

Plantago lanceolata.

1430 feet.

Trifolium repens.	Sedum rhodiola.

1370 feet.

Thalictrum minus.	Carduus palustris.

Salix aurita.

1330 feet.

Veronica chamaedrys.

1260 feet.

Antennaria dioica.

Level of Lugalougheaun.

1205 feet.

Ranunculus repens.	**Myriophyllum alterniflorum**
R. acris.	**Callitriche hamulata.**
R. flammula.	**Senecio aquatica.**
Subularia aquatica.	**Lobelia dortmanna.**
Alchemilla vulgaris (var. montana).	**Littorella lacustris.**
	Potamogeton natans.
Galium palustre.	**Sparganium minimum.**

Eleocharis palustris.

Down Outer Ridge, Southwards.

1100 feet.

Spirea ulmaria.	**Hedera helix.**
Lathyrus macrorrhizus.	**Dabeocia polifolia.**
Lonicera periclymenum.	**Erica tetralix.**

Schœnus nigricans.

1050 feet.

Carex glauca.

1020 feet.

Callitriche platycarpa.	Prunella vulgaris.

Carex vulgaris.

1010 feet.

Salix phylicifolia (upper limit).

1000 feet.

Juniperus nana.	Salix repens.

980 feet.

Potamogeton polygonifolius.	C. stellulata.
Carex ampullacea.	Lastrœa œmula.

900 feet.

Osmunda regalis.

750 feet.

Drosera anglica.	D. intermedia.

650 feet.

Pinguicula lusitanica.

DOWN OUTER RIDGE, SOUTHWARDS—*continued.*

550 feet.

Salix phylicifolia (lower imit).	Myrica gale.

300 feet.

Lycopodium selaginella.

DOWN CENTRAL (OWENAGLOCH VALLEY).

480 feet.

Cynosurus cristatus.	Equisetum sylvaticum.
Poa fluitans.	E. limosum.
Lastrœa oreopteris.	Pteris aquilina.

450 feet.

Pyrus aucuparia.	Fraxinus excelsior.
Ilex aquifolium.	Arundo phragmites.

DOWN CLIFFS S. E. TO LUGALOUGHAUN LAKE.

2240 feet.

Saxifraga stellaris.	Oxyria reniformis.

2100 feet.

Ranunculus acris.	Taraxacum dens-leonis.
Cardamine hirsuta.	Euphrasia officinalis.
Cerastium triviale.	Jasione montana.
Angelica sylvestris.	Aira alpina.
Chrysosplenium oppositifolium.	Lycopodium selaginoides.

1960 feet.

Valeriana officinalis (and at lake).

1650 feet.

Saxifraga stellaris. }
Oxyria reniformis. } (lower limit).

1400 feet.

Erica cinerea (upper limit).

Down South to Bunnaglass.

2500 feet.

Leontodon autumnale.

2400 feet.

Viola palustris.	Orchis maculata.

2000 feet.

Hypericum pulchrum.

1800 feet.

Thalictrum minus.	Carex rigida.

1600 feet.

Carex vulgaris.

1500 feet.

Erica cinerea.	Dabeocia polifolia.

1140 feet.

Salix repens.

1000 feet.

Carduus pratensis.

800 feet.

Erica tetralix. Myrica gale.	Carex fulva. Pteris aquilina.

700 feet.

Arctostaphylos uva-ursi (to sea).	Quercus robur.

500 feet.

Rosa pimpinellifolia.	Sedum anglicum.

130 feet.

Rubia peregrina.

100 feet.

Erica mediterranea.

ROUND RIDGE ABOVE L. BELLAWAUM TO LOUGH DOO, EASTWARDS.

2450 feet.

Cerastium triviale.	**Carex pilulifera.**

2000 feet.

Carex pulicaris.

1600 feet.

Hieracium anglicum.	**Molinia cœrulea.**

1450 feet.

Carduus pratensis.

1400 feet.

Pyrus aucuparia.

940 feet.

Pteris aquilina.

550 feet.

Carex pallescens.

ASCOKEERIN CLIFFS, EASTWARDS TO GLENCULLEN.

2660 feet.

Sedum rhodiola.	Carex rigida.

1640 feet.

Carex rigida.

1450 feet.

Thalictrum minus, to 400 feet.	Chrysosplenium oppositifolium.

Primula vulgaris.

400 feet.

Sanicula europœa.	Ilex aquifolium.

Betula vulgaris.

EAST OF L. BELLAWAUM TO TAWNYORNAN, SOUTHWARDS.

2500 feet.

Thymus serpyllum.	Aira alpina.

Lycopodium alpinum.

DOWN SOUTH TO BUNNAGLASS.

2500 feet.

Leontodon autumnale.

2400 feet.

Viola palustris.		Orchis maculata.

2000 feet.

Hypericum pulchrum.

1800 feet.

Thalictrum minus.		Carex rigida.

1600 feet.

Carex vulgaris.

1500 feet.

Erica cinerea.		Dabeocia polifolia.

1140 feet.

Salix repens.

1000 feet.

Carduus pratensis.

800 feet.

Erica tetralix. Myrica gale.		Carex fulva. Pteris aquilina.

700 feet.

Arctostaphylos uva-ursi (to sea).		Quercus robur.

500 feet.

Rosa pimpinellifolia.		Sedum anglicum.

130 feet.

Rubia peregrina.

100 feet.

Erica mediterranea.

To Doo Lough, North-eastwards—*continued.*

2100 feet.

Saxifraga stellaris.	**Aira alpina.**
Carex rigida.	**Lycopodium** selaginella.

2050 feet.

Galium saxatile.	**Pedicularis** sylvatica.
Sedum rhodiola.	**Lycopodium** selago.

1900 feet.

Carex rigida.

1480 feet.

Menyanthes trifoliata.	**Lycopodium** selago.

850 feet.

Hypericum androsœmum.	**Veronica** officinalis.

V. **chamædrys.**

670 feet.

Asplenium **adiantum-nigrum.**

650 feet.

Thalictrum minus.	**Hieracium** anglicum.
Bunium flexuosum.	**H. iricum.**

550 feet.

Sedum rhodiola.	Campanula rotundifolia.

Nardus stricta.

450 feet.

Asplenium trichomanes.

380 feet.

Rubus saxatilis.	Carex pallescens.

C. pilulifera.

350 feet.

Thalictrum minus.	**Hieracium** anglicum.

320 feet.

Jasione montana.	**Carex** pallescens.

250 feet.

Hypochæris radicata.	Corylus avellana.
Antennaria dioica.	Lastrœa œmula.

In addition to the alpine species already mentioned amongst the Mweelrea mountains, other local plants were noticed in new localities, and may be separately mentioned. There are *Rubia peregrina*, *Scrophularia aquatica*, *Carex pallescens*, *C. filiformis*, *Lotus major*, *Eriocaulon septangulare*, *Thalictrum minus*, *Utricularia intermedia*, *Habenaria albida*, *Sparganium minimum*, *Lycopodium clavatum*, *Œnanthe lachenalii*, *Œ. crocata*, and *Rubus saxatilis*.

On the south side of the valley of the Erriff, at the head of Killary fiord, and north of Joyce's river, a range of mountain forms the boundary between the counties Mayo and Galway. From Letterbrickaun, a village and hill about half a-mile east of Leenane, this high land extends, in a north-eastern direction, in a series of extensive and remarkably level table-lands, with numerous small and barren ponds and lakes, at an elevation of about 2000 feet for about six miles, when it gradually subsides. These mountains are variously called—Maumtrasna, Partry, and Letterbrickaun mountains, and the table-land is, I believe, Formnamore table-land. They are chiefly composed of sandstone and sandstone conglomerate, of carboniferous age, with considerable areas of granite and gneiss. The table-land is a waste of disintegrated conglomerate, and the whole chain is unusually barren. As on Croaghpatrick, *Carex rigida* is replaced by *Carex flava*. I have also noticed this on the Galtee mountains in Tipperary. The only alpine species observed were *Salix herbacea*, *Juniperus nana*, and the sub-alpine *Hieracium anglicum*. *Aira alpina*, an alpine form of *A. cæspitosa*, is abundant.

The following notes were taken :—

MAUMTRASNA AND LETTERBRICKAUN.

2150 feet.

Hieracium anglicum.

2130 feet.

Eriophorum polystachyon.

2120 feet.

Antennaria dioica.
Solidago virgaurea.
Campanula rotundifolia.
Calluna vulgaris.
Vaccinium myrtillus.
Juncus squarrosus.
Nardus stricta.
Aira alpina (and at 2100).

1850 feet.

Stellaria uliginosa (and at 1750).
Salix herbacea.
Carex flava.
Lycopodium selago.

MAUMTRASNA AND LETTERBRICKAUN—*continued.*

1800 feet.

Empetrum nigrum.

1750 feet.

Ranunculus ficaria.	**Epilobium** palustre.
Geum rivale.	**Erica cinerea.**

LETTERBRICKAUN, DOWN WEST.

2000 to 1950 feet.

Salix herbacea.

1900 feet.

Dabeocia polifolia.	**Orchis maculata.**

900 feet.

Bellis perennis.	**Carex vulgaris.**

DEVIL'S MOTHER, N.-WEST SIDE.

1900 feet.

Viola palustris.	Pinguicula vulgaris.

1520 feet.

Sparganium minimum.	Carex ampullacea.
Eriophorum angustifolium.	Juncus uliginosus.

MAUMTRASNA TO GOWLAN BRIDGE, NORTHWARDS.

1800 feet to 1350 feet.

Juniperus nana (upper inland limit).

800 feet.

Erica tetralix. }
Pteris aquilina. } Upper limit.

750 feet.

Myrica gale.

The last mountains considered (Maumtrasna) are partly in Mayo, partly in Galway, and they are apparently no great acquisition to either county, viewed botanically or in any other way.

Travelling southwards, we shall now take the Galway mountains in order, and there will be found on the whole a steady increase in the number of alpine plants. West of Leenane, on the Killary, the land rises at once to form another chain of mountains which stretches southwards to Maumturkmore. From this a ridge of dome-shaped quartzite mountains sweep round south-east and east to Maumeen, where there is a deeper valley than elsewhere, and then, bending more and more eastwards, it ends with the isolated lumps Corcogemore and Leckavrea (Shanafolia), above Lough Shindillia, at the Halfway-house from Clifden to Oughterard. The axis of this range would be probably about twenty miles; but after walking the whole length, summit after summit, from the Halfway-house to Leenane hotel, I concluded it to be nearer double that distance on foot. A zig-zag series of beehives best gives an idea of this remarkably bold and conspicuous range; each beehive being connected with its successor and predecessor by ridges, frequently several hundred, or even a thousand feet down, and usually altogether out of the lines of summits, and not even visible from them, so that compass bearings often lead one far astray. Add to this that the footing is mostly a loose detritus of heavy angular blocks of quartzite, bare of all sod or vegetation for miles, and it will readily be conceived that this is anything but a gentle day's stroll. These plateaux and truncated mounds seem more the shattered remnants of a mountain range that nature is endeavouring to efface, rather than soften with any of her charms. Wherever there appeared a chance I made detours and searched for varieties, and at the southern end of the chain, especially about Maumeen, which I examined carefully, I succeeded in finding a few, some of which had previously been observed; but, having passed that oasis, my object became more and more steadfastly fixed to hurry out of these interminable wastes before nightfall, and to visit them no more. The Maumturk range is the tangled cluster of the Twelve Bens, stretched out in a curved line with their tops rubbed off. The heights are about the same, commonly 2000 feet to 2400 feet, and all are chiefly quartzite. The chain has, however, lost most of its peaks, the compact mass of the Bens having been better able to resist the wearing action of the glacial period—during which time the ice-sheet appears to have buried the highest points of these mountains—and the denudation of subsequent times. The alpine species observed were:—*Thalictrum alpinum*, *Saxifraga oppositifolia*, *S. stellaris*, *Sedum rhodiola*, *Hieracium anglicum*, and its variety, *H. iricum*; *Juniperus nana*, *Salix herbacea*, *Isoetes lacustris*, *Lycopodium selaginella*, *L. alpinum*. Some other scarce species were observed, as: *Arabis hirsuta*, *Sagina subulata*, *Crepis paludosa*, *Hieracium vulgatum* (var. *gothicum*), *Listera cordata*, *Cystopteris fragilis*, and *Carex filiformis*; the latter only at the base of Leckavrea. *Saxifraga umbrosa* is, as usual, abundant; *Dabeocia polifolia* is an ornament upon

ll these mountains, south of Clew Bay. *Alchemilla subsericea* is a characteristic plant amongst the alpine species at Maumeen.

MAUMEEN, ABOVE LAKE; ROCKS LOOKING EAST AND NORTH.

1930 feet.

Sagina subulata.

1800 feet.

Alchemilla subsericea.

1650 feet.

Lycopodium selaginoides.

1580 feet.

Dabeocia polifolia.

1520 feet.

Thalictrum alpinum.	Sagina subulata.

1200 feet.

Arabis hirsuta. Hieracium anglicum. H. vulgatum (var. gothicum?).	Salix repens. Lastrea aculeata, and var. lonchitidioides.

1100 feet.

Linum catharticum. Alchemilla subsericea. Saxifraga oppositifolia. Lathyrus macrorrhizus. Crepis paludosa.	Hieracium vulgatum var. gothicum ?). H. iricum. Corylus avellana. Cystopteris fragilis.

910 feet.

Saxifraga oppositifolia (lower limit). Alchemilla vulgaris.	Fragaria vesca. Carex pulicaris. C. binervis.

Triodia decumbens.

LAKE.

770 feet.

Lobelia dortmanna. Carex stellulata.	Isoetes lacustris. Osmunda regalis.

Leckavrea to Maumwee Lough, South-easterly.

1810 feet.

Dabeocia polifolia.

300 feet.

Carex fulva.

100 feet.

C. filiformis.

Down Northwards.

1600 feet.

Sagina subulata.	Juniperus nana.

Corcogemore.

2000 feet.

Potentilla tormentilla.	Erica cinerea (upp
Galium saxatile.	Vaccinium myrtill
Saxifraga umbrosa.	Empetrum nigrum
Scabiosa succisa.	Juncus squarrosus.
Solidago virgaurea.	Carex vulgaris.
Campanula rotundifolia.	C. pilulifera.
Calluna vulgaris.	Aira flexuosa.

Lycopodium selago.

Down South.

1650 feet.

Listera cordata.

1500 feet.

Saxifraga umbrosa (disappears).

Down North-west.

1900 to 1600 feet.

Salix herbacea.

Summit, West of Corcogemore.

1900 feet.

Carex glauca.

SUMMIT, WEST OF CORCOGEMORE—*continued.*

1800 feet.

Sedum rhodiola.	Hieracium anglicum.

1700 feet.

Saxifraga stellaris.

RIDGE TO MAUMEEN, FROM EAST.

2000 to 1950 feet.

Antennaria dioica.	Salix herbacea.
Empetrum nigrum.	Lycopodium alpinum.

NORTH END OF RANGE; GLENCROFT ABOVE KILLARY.

300 feet.

Nasturtium officinale.	Carex paniculata.
Lychnis flos-cuculi.	Lastrœa oreopteris.

At the mouth of the Killary, opposite Mweelrea, and a little south the Little Killary, there stands an isolated mass of gneissose moun-ns, of which Benchoona, 1975 feet, is the highest point. From it another summit, about half a mile to the north-west, the surface is y slightly depressed and very rugged. There is a lake near this nd summit, at about 1800 feet, in which I gathered *Isoetes lacus-*, with fronds 15 inches long. This detached clump of mountains s not appear to have been previously visited by a botanist. I did n on the afternoon of a morning spent upon Mweelrea; taking a t across the Killary, and exploring across the hills above Salrock. as informed that the maiden-hair fern had been gathered in this hbourhood in quantity by an Englishman. I met with it nowhere in way. A few alpine species were noticed: *Thalictrum alpinum*, *racium anglicum* (var. *iricum*), *Salix herbacea*, and *Lycopodium sela-la; Thalictrum minus* and *Sagina subulata* were also gathered. two Thalictrums are, it will be seen, confined to distinct zones; latter being chiefly amongst loosely-constructed gneissose cliffs ing north-east. This rock is frequently uncommonly dangerous climb. About Salrock I gathered *Rubia peregrina*, which I also nd opposite on the Mweelrea side. In small lakes east of Lough , *Eriocaulon septangulare* is abundant, along with the two water-s, at about 200 feet above sea level. *Eleocharis multicaulis* is now haracteristic plant, and much more abundant than in Mayo. *Utri-aria intermedia* was gathered here also, and *Œnanthe crocata*, rare in

the west, was observed at Derry-na-Sliggan, on the shores of Ki Fiord, as was also *Carex flava* (var. *lepidocarpa*). This Œnanthe comes a sea-coast plant in the west of Ireland from Galway n wards.

BENCHOONA.

1970 feet.

Sagina subulata.

1900 feet.

Empetrum nigrum.	Salix herbacea (to 1680 f

1800 feet.

Littorella lacustris.	Isoetes lacustris.

1600 feet.

Thalictrum alpinum (to 1300 feet).

1500 feet.

Lycopodium selaginella.

900 feet.

Thalictrum minus (to 680 feet).	Hieracium anglicum (v iricum).

700 feet.

Asplenium ruta-muraria.

500 feet.

Alchemilla vulgaris.	Hymenophyllum unilater

Finally, there remains to be considered the mountainous distric Bennabeola—the Twelve Bens of Connemara. There are in rea seventeen more or less detached summits, from about 1500 to 2 feet in height. These are huddled together in a compact mass, the several valleys cut far into them. They are well known to all lo of mountain scenery, and their white and fantastic cluster of rug points and ridges is one of the chief beauties and attractions in Connemara district. The formation is chiefly quartzite; but, fo nately for botanists, one or two peaks are mainly composed of a m productive and tractable clayey schist. The valleys penetrating f thest to the heart of the mountains are, Glen Inagh from the e Glencoaghan from the south, and Owenglin from the west. No r leads up any of these valleys for much distance, and a guide wo

nvariably bring a visitor up some peak, probably Derryclare or Benlettery, to obtain his view of the scenery. In order to understand and properly appreciate these mountains, one should penetrate to the head of these glens and ascend them. Glencoaghan is, perhaps, the finest scenery; while Owenglin will lead the botanist to something worth his trouble.

Well-known mountains like these, within easy access of good roads and first-rate hotels, and famed far and wide for their scenery, would not be expected to yield fresh matter of interest. I found, however, a detached mountain peak here which was quite a treat to study botanically, so well does it illustrate the peculiar tastes of alpine plants, and such an interesting assemblage does it contain. To botanists this mountain has been *terra incognita*, and I appeal to them and others who may in future visit this locality to be chary of gathering specimens. In fact, were it not that my labours are the property of the Academy, and knowing how plants suffer, even to extermination, from the hands of predatory collectors, I would hesitate ere I disclosed my discovery.

Muckanaght, 2155 feet, is about two and a-half miles south of Kylemore: two other Bens, Benbaunbeg [1] and Benfree, intervene directly in this line, which was the route I took the first time I visited the northern side of Bennabeola. The upper half of this conical peak is disconnected; below that it is joined by necks to Benbaun south on the east, and Bencullagh on the west. From the summit it looks into the heart of Bennabeola on the east, opening up ravine, peak, and ridge in a most satisfactory manner, and is altogether the most picturesquely situated of the group, as well as the best for disclosing the "lay of the land." On the north it is connected by a ridge at about 1000 feet with Benfree; on the south it slopes in a series of abrupt declivities to the low valley at the head of Owenglin. The rock dips eastwards, exposing similar ledges on the north and south faces. No mountain could be better adapted for exhibiting the rigorous laws which govern the distribution of alpine plants. On the northern face at least a dozen species occur, several of these profusely. Half an hour's scramble will take us round to the south face, to a similar series of rocky declivities, and with the solitary exception of *Sedum rhodiola*, every alpine plant has disappeared, while lowland species take their place at the same level, several reaching unusually high. The change is remarkably well shown here, since in common with other mountains in the west, the alpine flora of Muckanaght is best developed at a zone of 1300 to 1800 feet, and fails gradually to the summit, so that keeping the same level around the side of the mountain, this gradual disappearance is very striking. *Salix herbacea* and *Carex rigida* are exceptions to the above general remark. These

[1] There are two Benbauns in the Twelve Bens; the northern and smaller one may be called Benbaunbeg.

usually—the former always—reach the summits of whatever m
tains they occur upon, but they are quite as rigorously confin
the northern and north-eastern faces, where all faces and side
exposed. *Carex rigida*, less abundant than *Salix*, does not
upon Muckanaght. The following alpine plants grow within
yards of one another upon this mountain :—

Thalictrum alpinum.	Hieracium anglicum.
Sedum rhodiola.	H. iricum.
Saxifraga umbrosa.	Oxyria reniformis.
S. oppositifolia.	Salix herbacea.
S. stellaris.	Polystichum lonchitis.
S. cœspitosa.	Asplenium viride.
Saussurea alpina.	Lycopodium selaginell

In company with these are ***Meconopsis cambrica***, ***Geum*** ***Crepis paludosa***, and ***Cystopteris fragilis***. Of these, three, ***Sa*** ***cœspitosa***, ***Saussurea alpina***, and ***Polystichum lonchitis***, have no previously found in the Mayo and Galway mountains, and se the others in only one or two localities. So great a variety o frages does not occur on any other Irish mountain. I have in ***S. umbrosa*** doubtfully with them to show this feature, as th mountain plant, it cannot be considered alpine in the same s the others. Immediately below the holly fern is a closely allie of *P. aculeatum*. I have noticed these in company before. A companionship exists here and elsewhere in Ireland between *nium trichomanes* and *A. viride*, so much so that on meeting e the lowland forms below, the others might almost be expecte if suitable situations occur. One other observation and I ha As if to heighten and illustrate the different atmospheric co of the two sides, a pair of ravens disputed my intrusion on th ern side in most audacious fashion, while a pair of peregrin selected the south side for their breeding ground. The rav home amongst plants which are abundant in the polar regions it also abounds: the peregrine, a more southern bird, is in with its surroundings. It is seldom these two species breed a of one another, and where they do they are at constant war. has here allotted to each its own fit and suitable domain.

There is another station for alpine plants amongst the Bens—Ben Lettery—which has been examined by botanist point lies about two and a-half miles south of Muckanaght the wide valley at the head of the Owenglin river, and is ately above Ballynahinch Lake and the public road on the sout northern face thus looks out on Muckanaght, and though the s side and upper parts from the summit to about 1500 feet are and composed of quartzite, yet below that level schistose ro with them alpine plants, appear. ***Lycopodium alpinum*** and ***Th*** ***alpinum*** have been recorded from here by Wade. The latter

as been verified by Isaac Carroll, who has also recorded *Saxifraga oppositifolia* and *Asplenium viride*. The rarest species, *Saussurea alpina*, which is plentiful on the same ground, has not been recorded. I could ot, however, meet with *Lycopodium alpinum* on Bennabeola; although eing a plant fond of siliceous soil, and occurring elsewhere in the eighbourhood, it is likely enough to occur, and may have been passed ver. On Ben Lettery, the upper limit of the alpine species is simply etermined by the change of rock to quartzite.

BENCORR AND BENBAUN, DOWN NORTH TOWARDS KNOCKPASHEEMORE.

2390 to 2310 feet.

Potentilla tormentilla.	Scirpus cœspitosus.
Galium saxatile.	Carex binervis.
Saxifraga umbrosa.	C. pilulifera.
Euphrasia officinalis.	Anthoxanthum odorantum.
Calluna vulgaris.	Aira flexuosa.
Vaccinium myrtillus.	Agrostis vulgaris.
Empetrum nigrum.	Lastrœa dilatata.
Juncus squarrosus.	Polypodium vulgare.

Lycopodium selago.

2250 feet.

Silene maritima.	Armeria maritima.
Solidago virgaurea.	Aira cœspitosa.

1900 feet.

Dabeocia polifolia.

1850 feet.

Stellaria uliginosa.

1800 feet.

Molinia cærulea.	Erica cinerea.

1200 feet.

Pyrus aucuparia.

800 feet.

Hymenophyllum unilaterale.

BENBAUNBEG, DOWN NORTH TO KYLEMORE.

1570 feet.

Antennaria dioica.	Salix herbacea.

BENBAUNBEG, DOWN NORTH TO KYLEMORE—*continued.*

820 feet.

Carex pallescens.

750 feet.

Alchemilla vulgaris (var. subsericea).

700 feet.

Quercus robur.	Salix repens.

Lastrœa aculeata.

BENBRACK SUMMIT.

1900 feet.

Salix herbacea.

SOUTH SIDE.

1020 feet.

Asplenium trichomanes.

BENGOWER DOWN SOUTH, TO GLENCOAGHAN.

1200 feet.

Lastrœa œmula.

650 feet.

Mentha aquatica.

250 feet.

Eleocharis multicaulis (most abundant).

DERRYCLARE, DOWN SOUTH.

2300 feet.

Pyrus aucuparia.

2060 feet.

Antennaria dioica.

DERRYCLARE, DOWN SOUTH—*continued.*

2000 feet.

abiosa succisa. | Orchis maculata.
Molinia coerulea.

1800 feet.

Arctostaphyllos uva-ursi (abundant).

1600 feet.

Dabeocia polifolia.

950 feet.

Erica tetralix.

BEN LETTERY, SOUTH SIDE.

1500 feet.

xifraga umbrosa. | Solidago virgaurea.
Carex pilulifera.

1450 feet.

beocia polifolia. | Erica cinerea.
Lastræa æmula.

1150 feet.

Juniperus nana.

1100 feet.

Lycopodium selago.

950 feet.

Erica tetralix (upper limit).

800 feet.

Schœnus nigricans.

650 feet.

Eleocharis multicaulis (upper limit).

420 feet.

pericum androsæmum. | Triodia decumbens.

BEN LETTERY, NORTHERN SIDE.

1520 feet.

Thalictrum alpinum.	Saxifraga oppositifolia.

Asplenium viride.

1420 feet.

Saussurea alpina.	Plantago lanceolata.

1320 feet.

Rubus saxatilis.	Saussurea alpina.

Lycopodium selago.

1310 feet.

Saxifraga oppositifolia (lower limit).

1300 feet.

Thalictrum alpinum (lower limit).

800 feet.

Drosera rotundifolia.	Erica tetralix.
Crepis paludosa.	Pinguicula lusitanica.

600 feet.

Carex fulva.

MUCKANAGHT, DOWN SOUTH SIDE.

2150 feet.

Calluna vulgaris.	Eriophorum vaginatum.
Thymus serpyllum.	Luzula sylvatica.

And most of the commoner summit species on BEN CORR, and elsewhere.

2000 feet.

Blechnum boreale.

1400 feet.

Hieracium vulgatum (var. gothicum).	Carduus pratensis.
	Pinguicula vulgaris.

Nardus stricta.

MUCKANAGHT, SOUTH SIDE—*continued.*

1350 feet.

Lathyrus macrorrhizus.
Scabiosa succisa.
Antennaria dioica.
Prunella vulgaris.
Plantago lanceolata.
Schœnus nigricans.

1250 feet.

Lonicera periclymenum.
Hedera helix.
Ilex aquifolium.
Hieracium vulgatum.
Teucrium scorodonia.

1150 feet.

Lotus corriculatus.
Sedum rhodiola.
Crepis paludosa.
Hieracium vulgatum.
Plantago maritima.
Triodia decumbens.
Lastrœa filix mas.
L. filix foemina.
Asplenium adiantum nigrum.
A. ruta-muraria.
A. trichomanes.
Polypodium vulgare.

MUCKANAGHT, DOWN NORTH SIDE.

2130 feet.

Saxifraga stellaris.
Salix herbacea.
Cystopteris fragilis.

2110 feet.

Thalictrum alpinum.
Luzula campestris.
Carex panicea.
Poa annua.

2050 feet.

Aira cœspitosa.

1900 feet.

Oxyria reniformis.
Oxalis acetosella.
Asplenium viride.

1850 feet.

Ranunculus flammula.

1700 feet.

Thalictrum alpinum (lower limit).
Geum rivale.
Sedum rhodiola.
S. oppositifolia.
S. stellaris.
Saussurea alpina.
Oxyria uniformis.

MUCKANAGHT, DOWN NORTH SIDE—*continued.*

1700 feet—*continued.*

Plantago maritima. | Carex panicea.
Asplenium viride.

1600 feet.

Cystopteris fragilis (lower limit).

1500 feet.

Meconopsis cambrica.	Saussurea alpina
Geum rivale.	Polystichum lonc
Saxifraga cœspitosa.	P. lonchitoides.
Hieracium anglicum.	Lycopodium sela

1470 feet.

Meconopsis cambrica.
Sedum rhodiola.
Saxifraga oppositifolia.
S. stellaris.
S. cœspitosa.
Oxyria reniformis.
Asplenium viride.
} Lower limit

1080 feet.

Asplenium trichomanes. | Hymenophyllum

At the lower levels in this part of Galway the cou thoroughly well ransacked. I did not feel called upon detailed search, therefore. The following are a few notes bases of the mountains:—Derryclare Lough, below De *Drosera intermedia* very abundant; *Subularia aquatica, intermedia, Carex limosa,* and *Eriocaulon septangulare,* all Kylemore I saw *Hieracium iricum,* and between that a Sliggan, *Helosciadium nodiflorum, Veronica scutellata,* and On the north side of Ballinahinch Lake, in bogholes by may be seen *Cladium mariscus, Carex limosa,* and *C. filifo*

I shall now give a general list, including all the mou observed, starting at the highest point attained by each, ing their other more important altitudes throughout the t This list, which is the result of the more local one, has b compilation, but appeared to me quite necessary. Some s racies, arising from confusion of figures, may have crep have failed to detect any.

GENERAL LIST OF PLANTS

bserved on the Mayo and Galway Mountains, *arranged in descending order.*

Summit of Mweelrea.

2680 feet.

otentilla tormentilla (Nestl.)—Nephin, 2640; Croaghpatrick, 2510, &c., and downwards. Abundant.

axifraga umbrosa (Linn.)—All summits, and downwards to sea-level, near the coast in dry, stony places. Occurs on all aspects, being at home either amongst alpine plants, or where they could not exist. Inland it rarely occurs as a lowland plant, ceasing downwards at 1500 to 1200 feet. No choice of rock.

alluna vulgaris (Salisb.)—All summits and downwards. Abundant.

accinium myrtillus (Linn.)—Ditto.

hymus serpyllum (Linn.)—Bengorm, 2200; Croaghpatrick, 1570; Twelve Bens, 2150. Not ascending many mountains, though frequent at considerable heights on the Mweelrea group. Common below. Will not grow on the quartzite.

Rumex acetosa (Linn.)—Summits of all the Mayo mountains, and downwards.

R. acetosella (Linn.)—Croaghpatrick summit. Not universally distributed at upper heights. Re-appearing commonly below.

uncus squarrosus (Linn.)—Summit of Croaghpatrick; Twelve Bens, 2390.

uzula sylvatica (Bich.)—Summits of Mayo mountains. Twelve Bens, 2150. Shady cliffs or woods in lowland districts. Rarely on open ground except at mountain summits; usually abundant there.

. campestris (Willd.)—Bengorm, 2200; Twelve Bens, 2110. Increasing quickly to open moors. Frequent.

riophorum vaginatum (Linn.)—Twelve Bens, 2150. Continuous to low levels on moors.

arex pilulifera (Linn.)—Corslieve, 2025; Twelve Bens, 2390. Frequent to about 1200 feet. Scarce at low levels.

. binervis (Sm.)—Croaghpatrick, 2350; Twelve Bens, 2390. Very glaucous on Mweelrea. On open moors.

cirpus cæspitosus (Linn.)—Twelve Bens, 2390.

nthoxanthum odoratum (Linn.)—Summits of Mayo mountains. Twelve Bens, 2390. Frequent.

ardus stricta (Linn.)—Maamtrasna, 2120. Soon abundant in dry situation, from 1500 feet downwards, and thrives on the quartzite.

Aira cæspitosa (Linn.)—Twelve Bens, 2250. Common in the Mayo mountains at high levels.

Agrostis vulgaris (With.)—Twelve Bens, 2390.

Festuca ovina (Linn.)—Summits of Nephin and Croaghpatrick. Twelve Bens, 2150.

SUMMIT OF NEPHIN.

2640 feet.

Galium saxatile (Linn.)—Summit of Croaghpatrick. Twelve Bens, 2390; Leckavrea, 2000. Abundant.

Empetrum nigrum (Linn.)—Summit of Croaghpatrick. Corslieve, 2250; Twelve Bens, 2350. Common. Below 300 feet on Achill and Birreencorragh. One of the few species that thrives on quartzite.

Armeria maritima (Willd.)—Mweelrea, 2640. Summit of Croaghpatrick. Twelve Bens, 2250. Ceases as a mountain plant. Croaghpatrick, 1500; Curraun Achill, 1200. Re-appearing abundantly at sea level, and thriving on siliceous rocks.

Aira flexuosa (Linn.)—Mweelrea, 2600. Summit of Croaghpatrick. Twelve Bens, 2390. Common on moorlands.

Lastrœa dilatata (Presl.)—Mweelrea, 2380; Twelve Bens, 2390.

Lycopodium selago (Linn.)—Twelve Bens, 2390. Sea level, or near it at Doo Lough. Ceases usually at about 1200 to 1000 feet on the mountains as on Nephin. Seems to prefer siliceous rocks.

MWEELREA.

2600 feet.

Sedum rhodiola (D. C.)—Not seen elsewhere nearly so high. Descends occasionally to sea level; but usually found in alpine situations and with alpine plants. Croaghpatrick, 1740 to 1570; Corslieve, 1600; Achill, 1430 to sea level; Mweelrea, 1430 to 500; Corcogemore, 1800; Twelve Bens, 1700 to 1470, and at 1170.

Solidago virgaurea (Linn.)—Achill, 1730; Twelve Bens, 2250; Maamtrasna, 2120; Leckavrea, 2000.

Campanula rotundifolia (Linn.)—Ben Gorm, 2150; Croaghpatrick, 1900; Corcogemore, 1900; Maamtrasna, 2000. Not unfrequent as a mountain plant, especially in rocky ground of a siliceous nature. Descending to 550 feet on cliffs above Doo Lough; but flowers sparingly.

Melampyrum pratense (Linn.) (var. *montanum.*)—Nephin, 2300; Corslieve, 2250; Croaghpatrick, 1900; Achill, 1730. Rather thinly distributed, and not met with at low levels.

Plantago maritima (Linn.)—Curraun Achill, 1200; Achill, 2200; Twelve Bens, 1700. Rarely occurring inland at low levels. At the base of Nephin in Boughadoon, by the Glenlaur river,

and by Fin Lough. A curiously stunted variety, with broad leaves, and stem an inch and a-half high, occurs at 2400 to 2300 on the Ascokeerin ridge, Mweelrea; and on the summit of Delphi mountain, 2550.

Salix herbacea (Linn.)—Nephin, 2450 to 1880; Corslieve and Nephinbeg, 2320 to 1700; Curraun Achill, 1560; Achill, 2100 to 1900; Croaghpatrick, 1850 to 1750; Mweelrea group, to 1850; Maamtrasna range, 1850; Maamturk range, 2000 to 1600; Benchoona, 1900 to 1680; Twelve Bens, 2130 to 1570. Possibly occurs lower on low summits, since it prefers the tops and ridges of mountains in perfectly exposed situations. This is the commonest alpine plant, and occurs on very nearly all the mountains I visited. More abundant on Mweelrea than elsewhere; on the northern summit it is the chief vegetation straggling amongst moss.

x rigida (Good.)—Nephin, 2500; Corslieve and Nephinbeg, 2320 to 1600, and at 860 feet at Scardaun Lake; Achill, 2030 to 1825; Mweelrea group, to 1640. Next to the last, this is the commonest truly alpine species in the west; they are frequently in company on wet ledges, and both thrive on the quartzite.

Mweelrea.

2590 feet.

ymenophyllum unilaterale (Willd.)—Corslieve, 1750; Achill, 1730; Ben Gorm, 2080. Frequent at low levels in both counties.

Delphi Mt. (Mweelrea Group).

2550 feet.

hillea millefolium (Linn.)—At 2350 above Lough Brawn on Loughty Mt. Met with nowhere else on the mountains; here it was stunted, consisting of a few rigid radical leaves without stem or flowers. Frequent below.

antago lanceolata (Linn.)—A very diminutive form, with slightly succulent, narrow, lanceolate leaves, about an inch in length, and a flowering stem not much higher. Resembles the form of *P. maritima*, mentioned above, in general appearance. Ordinary *P. lanceolata* finds upper limits—on Croaghpatrick, 1630; Mweelrea, 1520.

Summit of Croaghpatrick.

2510 feet.

a annua (Linn.)—Ben Gorm and Glenamorig, 2200; Buckoogh and Mweelrea, 1900. Accidentally distributed amongst these heights. Probably the seeds are transported hither by sheep, as this grass only occurred at great heights in the neighbourhood of their runs.

MWEELREA.

2500 feet.

Leontodon autumnalis (Willd.) (var. *taraxaci.*)—Ridge above Brawn, 2350; Mweelrea, 1500 (*L. autumnalis.*) Thence co
Aira cæspitosa (Linn.) (var. *alpina.*)—To 2100; Ben Gorm, Maamtrasna, 2120 to 2100. Not met with on the Twelv or other Galway mountains, and only occurring at great h Plentiful in some parts of Mweelrea, and on Maamtrasna (more) table-land.
Lycopodium alpinum (Linn.)—Ridge above Lough Brawn, 2450 raun Achill, 1560; Maamturk range, 2000 to 1950. Thi *Salix herbacea* and *Carex rigida*, are the only truly alpine which grow on the quartzite mountains. They, especia present species, appear to prefer a siliceous soil. Plen each locality cited.

NEPHIN.

2450 feet.

Saxifraga stellaris (Linn.)—To 2400; Nephinbeg and Corslie to 1400; Achill, 2080 to 1825; Mweelrea, 2300 to 16 1050 in Glenlaur; Twelve Bens, 2240 to 1650; Maamtur 1700. Rather sparingly distributed.

MWEELREA.

2450 feet.

Cerastium triviale (Link.)—And at 2100; Croaghpatrick, 1370 dant below. Scarce at high levels.

RIDGE ABOVE LOUGH BRAWN, LOUGHTY MT. (MWEELREA GR

2400 feet.

Geum rivale (Linn.)—Maamtrasna, 1750; Twelve Bens, 1850 A local plant, and not seen elsewhere. Not on the quart
Saxifraga oppositifolia (Linn.)—Maamturk range, 1100 to 910; Bens; Ben Lettery, 1520 to 1310; Muckanaght, 1700 t Exceedingly scarce in the only Mayo locality. More ple Muckanaght; but rare in Galway also. Never on quartzi
Antennaria dioica (Gœrt.)—To low levels at Doo Lough. Oc most of the mountains, quartzite or otherwise, from abo to 1000.

tis-idæa (Linn.)—Very scarce, and unhealthy-looking here. ant has been recorded from several of the mountains I ed in Mayo and Galway, but I found it only in the present n. It appeared to me very rare indeed, and I was always look out for it.

formis (Hook.)—Ben Gorm, 2080; Mweelrea, 2240 to Croaghpatrick, 1740 to 1570; Twelve Bens (Muckanaght), 1470. Very scarce. On Croaghpatrick it is plentiful, y large and luxuriant. In the present locality it is very Never on quartzite.

ragilis (Bernh.)—Very rare in this the only Mayo habitat. rk range (Maumeen), 1100; Twelve Bens (Muckanaght), 1600. Very rare in the west, and quite alpine in its in localities; does not occur on the quartzite.

MWEELREA.

2400 feet.

ris (Linn.)—Maamtrasna, 1900; Ben Gorm, 2030.

ata (Linn.)—Maamtrasna, 1900; Mweelrea, 2300; Twelve 000.

a (Linn.)—Ben Gorm (Mweelrea group), 2050; Croagh- 1650; Twelve Bens (Muckanaght), 2110 feet. Remark- xuriant and glaucous, with glumes and fruit concolorous, lack, on drooping spikelets in alpine situations on Mucka-

TWELVE BENS.

2390 feet.

fficinalis (Linn.)—Mweelrea, 2100; Croaghpatrick, 1740. t high levels.

ulgare (Linn.)—Mweelrea, 2380. Soon becoming common.

MWEELREA.

2380 feet.

x-mas (Presl.)—Twelve Bens, 1150; var. *abbreviata*, at a Croaghpatrick. Not plentiful.

ABOVE LOUGH BRAWN.

2350 feet.

polystachyon (Linn.)—Buckoogh, 1920; Ben Gorm, 2050; asna, 2130.

TWELVE BENS.

2300 feet.

Pyrus aucuparia (Gœrt.)—Corslieve, 1700; Mweelrea, 1
lings, or dwarfed above 1000. Frequent below, and
at the base of Nephin.

MWEELREA.

2250 feet.

Blechnum boreale (Sm.)—Croaghpatrick, 1740; Ben (
Twelve Bens, 2000. Only locally plentiful, and d
on the quartzite.

TWELVE BENS.

2250 feet.

Silene maritima (With.)—Nephin, 1870; Birreencorra
sea-coast plant ascending mountains in the maritime
Armeria maritima and *Plantago maritima*, and, like
siliceous soil, or on the quartzite.

ACHILL.

2200 feet.

Oxalis acetosella (Linn.)—Corslieve, 2000; Ben Gorm, 1
Bens, 1900. Common at lower levels from abo
downwards.

Jasione montana (Linn.)—Ben Gorm, 2220; Croaghp
Mweelrea, 2100. Not seen so high in Galway; n
below 1500 feet, especially on siliceous soil.

BEN GORM (MWEELREA GROUP).

2150 feet.

Viola sylvatica (Fries.)—At this height var. *Reichenbachia*
patrick, 1900. Frequent lower; apparently dislike

MAAMTRASNA RANGE.

2150 feet.

Hieracium anglicum (Fries.)—Nephin, 1490; Achill, 14
patrick, 1650; Mweelrea, 1600 and 1520 to 650 a
Doo Lough. Maamturk range, 1800 to 1200; T

1500. Usually alpine, but occasionally found at low levels in Mayo; it is then sometimes indistinguishable from *H. iricum*, which, I believe, is a luxuriant lowland form. Typical *H. iricum* never occurs higher up, or in alpine situations. It may be seen along the roadside at Kylemore and elsewhere. The two forms graduate into one another about Doo Lough and Maumeen.

TWELVE BENS (MUCKANAGHT).

2110 feet.

halictrum alpinum (Linn.)—To 1700, and on Ben Lettery, 1520 to 1300; Maamturk (Maumeen), 1520; Benchoona, 1600 to 1300; Croaghpatrick, 1590 to 1570. Apparently on all rocks except quartzite. Like *Lycopodium alpinum*, it seems especially fond of granite or gneiss.

MWEELREA.

2100 feet.

anunculus acris (Linn.)—Not noticed ascending to any considerable height elsewhere. Frequent from about 1200 downwards.

rdamine hirsuta (Linn.)—Croaghpatrick, 1650. Not common at any considerable height.

gelica sylvestris (Linn.)—And at 1900; Croaghpatrick, 1590. Not seen elsewhere higher up.

rysosplenium oppositifolium (Linn.)—And at 1450. Rare on the mountains.

raxacum dens-leonis (Desf.)—Croaghpatrick, 1590.

copodium selaginoides (Linn.)—To 300; Maamturk (Maumeen), 1650; Twelve Bens, 1500 to 1320.

BEN GORM (MWEELREA GROUP).

2050 feet.

rica cinerea (Linn.)—Nephin, 1750; Birreencorragh, 1500; Nephinbeg, 1425; Croaghpatrick, 1690; Mweelrea, 1500 and 1400; Maamtrasna, 1750; Maamturk range, 2000; Twelve Bens, 1800 and 1450. Stunted and scattered above 1600 feet, and hardly general anywhere above 1500.

inguicula vulgaris (Linn.)—And at 1940; Buckoogh, 1920; Achill, 1480; Croaghpatrick, 1590; Maamtrasna, 1900; Twelve Bens, 1450. The lower of these upper limits arises from unsuitability of ground; common below.

arthecium ossifragum (Huds.)—Glenamorig, 1750; Achill, 1480. Abundant below.

MWEELREA.

2050 feet.

Pedicularis sylvatica (Linn.)—And at 2000. Sparingly distributed high levels in these mountains.

BEN GORM (MWEELREA GROUP).

2050 feet.

Carex flava (Linn.)—Croaghpatrick, 1850; Achill, 1730; Curra Achill, 1560; Mweelrea, 1900; Maamtrasna, 1850.

DELPHIN MT. (MWEELREA GROUP).

2000 feet.

Equisetum palustre (Linn.)—Very unusually high for this plant.

MWEELREA.

2000 feet.

Hypericum pulchrum (Linn.)—Frequent lower.
Carduus pratensis (Huds.)—Birreencorragh, 1100; Mweelrea, 145 Twelve Bens, 1450. Rarely extending above 1000 feet.
Carex pulicaris (Linn.)—Not frequent till about 1000 feet, as ab Doo Lough and on Muckanaght.

MAAMTURK RANGE.

2000 feet.

Scabiosa succisa (Linn.)—Buckoogh, 1880; Croaghpatrick, 165 Twelve Bens, 2000. Common lower.
Carex vulgaris (Fries.)—Buckoogh, 1180; Mweelrea, 1600. Seld occurring at any considerable height. Common below.

TWELVE BENS.

2000 feet.

Molinia cærulea (Mœnch.)—Mweelrea, 1600. Soon becoming comm

BENCHOONA.

1970 feet.

Sagina subulata (Wim.)—Maamturk range, 1930 to 1520. In crevic on the barren exposed summits of gneissose or quartzite mou tains. Rare, but easily overlooked.

MWEELREA.

1960 feet.

... officinalis (Linn.)—And at 1200. Not unfrequent at the ...e of the mountains.

BUCKOOGH.

1920 feet.

...fusus (Linn.)—Achill, 1480. Then common.

MWEELREA.

1900 feet.

...ulus ficaria (Linn.)—And at 1205. Maamtrasna, 1750.
... uliginosa (Murr.)—Croaghpatrick, 1370; Maamtrasna, ...0; Twelve Bens, 1850.
... purpurea (Linn.)—Croaghpatrick, 1280; Ben Gorm, ...0.
... vulgaris (Huds.)—Croaghpatrick, 1650.

Common below.

MAAMTRASNA RANGE.

1900 feet.

...polifolia (Don.)—Croaghpatrick, 1390; Loughty Mt., 1750; ...eelrea, 1500; Maamturk, 1810; Twelve Bens, 1900. Though ...h less abundant, this plant has about the same vertical range ...*Erica cinerea*. The two frequently appear simultaneously.

BEN GORM.

1900 feet.

...um clavatum (Linn.)—Not met with elsewhere.

MAAMTURK RANGE.

1900 feet.

...usca (Scop.)—Mweelrea, 1050. Frequent lower down.

TWELVE BENS (MUCKANAGHT).

1900 feet.

... viride (Huds.)—Croaghpatrick, 1800 to 1570; Twelve ...—Ben Lettery, 1520; Muckanaght, 1900 to 1470.

CROAGHPATRICK.

1630 feet.

Senecio jacobæa (Linn) } Rarely ascending the mountain
Rhinanthus crista-galli (Linn.) }

MWEELREA.

1600 feet.

Asplenium trichomanes (Linn.)—Achill, 1430; Croaghpatrick, 1[illegible] Twelve Bens, 1150.

CROAGHPATRICK.

1590 feet.

Ranunculus repens (Linn.)—Mweelrea, 1205.
Polygala vulgaris (Linn.)—Not commonly occurring at this height, not so frequent on the mountains as *P. depressa*.

DELPHI MT. (MWEELREA GROUP).

1550 feet.

Rosa spinosissima (Linn.)—Mweelrea, 500. Frequent lower down.
Lonicera periclymenum (Linn.)—Mweelrea, 1100. Abundant below
Juniperus communis (Linn.)—This form is rarely seen high up, whe it usually becomes *J. nana*.

MWEELREA.

1520 feet.

Lathyrus macrorrhizus (Winn.)—And at 1100; Maamturk rang 1100; Twelve Bens, 1350.

MAAMTRASNA.

1520 feet.

Sparganium minimum (Fries.)—Buckoogh (Lake Nambrackheagh 1180; Mweelrea (L. Lugaloughaun), 1205.
Juncus uliginosus (Sm.) } Frequent below.
Carex ampullacea (Good.)—Mweelrea, 980. }

MAAMTURK RANGE.

1520 feet.

m vulgatum (Fries., Var. *gothicum*)—To 1100 feet; Twelve
s, 1400. This and *H. vulgatum* graduate into one another on
south side of Muckanaght.

DELPHI MT. (MWEELREA GROUP).

1500 feet.

ba (Linn.)—Delphi Mt., 630; Mweelrea, 750.

MWEELREA.

1500 feet.

s montanum (Linn.)—Rarely seen at any considerable height.

TWELVE BENS (MUCKANAGHT).

1500 feet.

s cambrica (Vig.)—To 1470. This rare species was in full
er when I discovered it here, and was then remarkably showy
handsome. The flowers were fully two inches in diameter.
cæspitosa (Linn.)—To 1480. See introductory remarks.
um lonchitis (Roth.)—Sparingly distributed, and growing
ediately over the following closely resembling form.
tum (Roth.) (var. *lonchitidiodes.*)—Maamturk range, 1200.
inclined to think the holly fern grows in this latter locality

um (Roth.)—Maamturk range, 1200; Twelve Bens, 700.

ACHILL.

1480 feet.

lepressa (Wend.)—Soon common.

MWEELREA.

1480 feet.

s trifoliata (Linn.)—Not seen again for about 1000 feet;
frequent.

MWEELREA.

1450 feet.

s pratensis (Linn.)—Croaghpatrick, 1370.

ACHILL.

1430 feet.

Hymenophyllum tunbridgense (Sm.)—Nephin range, 400.

MWEELREA.

1430 feet.

Trifolium repens (Linn.)—Buckoogh, 1180; Croaghpatrick,

CROAGHPATRICK.

1370 feet.

Myosotis repens (Don.)—Apparently scarce.
Callitriche stagnalis (Scop.)—Mweelrea, 1020. Rare on t
tains.

MWEELREA.

1370 feet.

Carduus palustris (Linn.)—And at 1150. A characteristic pl
and very luxuriant by the Glenlaur river. Plants here l
an inch and a-half across, and on two or three occasion
was branched, bearing three or four large flowers toget

MWEELREA.

1350 feet.

Salix caprœa (Linn.)—Not common for a few hundred feet.

TWELVE BENS.

1350 feet.

Prunella vulgaris (Linn.)—Mweelrea, 1020; Birreencorra
Rarely on the mountains.
Schœnus nigricans (Linn.)—And at 850. Ben Gorm, 1100;
1100. Plentiful in many places from about these heigh

MWEELREA.

1330 feet.

Veronica chamædrys (Linn.)—And at 850. Soon frequent.

NEPHINBEG.

1325 feet.

natus (Linn.)—Birreencorragh, 1100. On upper pastures.

CROAGHPATRICK.

1300 feet.

ilina (Linn.)—Birreencorragh, 600; Delphi Mt., 800; Ben a, 750; Mweelrea, 940 and 800; Maamtrasna, 800. Not dant, and apparently averse to quartzite. I have given all upper limits I observed, since this and *Erica tetralix* are son's test-plants for the upper margin of his "sub-arctic ."

NEPHIN.

1290 feet.

ralix (Linn.)—Birreencorragh, 1200; Croaghpatrick, 1170; hty Mt. (Glenlaur), 770; Ben Gorm, 800; Mweelrea, 1100 800; Maamtrasna, 800; Twelve Bens, 950 and 800. See r *Pteris aquilina*. The mean of these levels places this plant ndred feet above Pteris, which is nearer the truth than their ive position in this summary.

LOUGHTY MT. (GLENLAUR).

1250 feet.

rennis (Linn.)—Birreencorragh, 1100; Maamtrasna, 900. ly ascending the mountains.

TWELVE BENS.

1250 feet.

olium (Linn.)—Delphi Mt., 600; Mweelrea, 450. Frequent ever any natural wood remains, and in rocky slopes lower
.

scorodonia (Linn.)—Scarce till the valleys are reached.

MWEELREA (LAKE LUGALOUGHAUN).

1205 feet.

aquatica (Linn.)—Abundant in Derryclare and Ballinahinch . This lake is erroneously recorded in "Flora Hibernica" 00 feet above the sea.

Alchemilla vulgaris (Linn.)—Maamturk range, 910; Benchoons, 500. Frequent along the bases of the mountains, especially in Connemara.

Galium palustre (Linn.)—Abundant at low levels.

Myriophyllum alterniflorum (D. C.)—Abundant in the larger lakes below.

Senecio aquaticus (Huds.)—Not seen elsewhere high up, but occurs continuously along the stream from this lake to the base.

Lobelia dortmanna (Linn.)—Buckoogh, 1180; Nephinbeg (Scardaun Lake), 860.

Callitriche hamulata (Kutz.)—A common lake plant in the west.

Potamogeton natans (Linn.)—Buckoogh, 1180. Rare high up, and seldom flowering. In turfy lakes and bog-holes this plant is most variable. The leaves every shape, from linear to ovate.

Eleocharis palustris (R. Br.)—Rare in elevated stations.

CURRAUN ACHILL.

1200 feet.

Lotus corniculatus (Linn.)—Twelve Bens, 1150. Not common till low levels are reached.

MAAMTURK RANGE.

1200 feet.

Arabis hirsuta (R. Br.)—Not seen elsewhere.

TWELVE BENS.

1200 feet.

Lastræa æmula (Brack.)—Mweelrea, 980, and lower; Croaghpatrick, 630. Not plentiful amongst the mountains.

MAAMTURK RANGE.

1200 feet.

Salix repens (Linn.)—Mweelrea, 1000, 1140; Twelve Bens, 700. Then abundant along the maritime mountains.

TWELVE BENS.

1150 feet.

Triodia decumbens (Beauv.)—Maamturk range (Maumeen), 910. Soon common.

Lastræa filix-fœmina (Presl.)—Abundant below.

Asplenium adiantum-nigrum (Linn.)—Mweelrea, 670. Frequent.

A. ruta-muraria (Linn.)—Benchoons, 700. Rare on mountain cliffs.

BIRREENCORRAGH.

1100 feet.

Linum catharticum (Linn.)—Abundant when dry pastures are reached.

BEN GORM.

1100 feet.

Drosera rotundifolia (Linn.)—Twelve Bens, 800. Then common.

MWEELREA.

1100 feet.

Spiræa ulmaria (Linn.)—Frequent lower down.
Equisetum sylvaticum (Linn.)—Corslieve, 600; Mweelrea, 480. Not unfrequent lower down.

TWELVE BENS.

1100 feet.

Hieracium vulgatum (Fr.)—On Muckanaght, south side, where it varies into *H. vulgatum*, var. *gothicum*.
Corylus avellana (Linn.)—Mweelrea, 250. Frequent below. Very large hazels grow in Boughadoon at the base of Nephin.

LOUGHTY MT. (MWEELREA GROUP).

1050 feet.

Montia fontana (Linn.)—Glenlaur.

MWEELREA.

1010 feet.

Salix phylicifolia (Linn.)—To 550. Not seen elsewhere.

DELPHI MT. (MWEELREA GROUP).

1000 feet.

Orchis latifolia (Linn.)—Seldom occurs so high up, or even nearly as high.
Carex fulva (Good.)—Mweelrea, 800 and 500; Twelve Bens, 600. Not unfrequent on boggy slopes at the mountain bases.

MWEELREA.

980 feet.

Potamogeton polygonifolius (Pourr.)—Abundant in the lower bogs.
Carex stellulata (Good.)—Maamturk range, 770. Probably oc higher, but I did not meet with it. Abundant lower.

MAAMTURK RANGE.

910 feet.

Fragaria vesca (Linn.)—Soon frequent.

MWEELREA.

900 feet.

Osmunda regalis (Linn.)—Maamturk range (Maumeen), 770. Frequ in glens, and by streams lower down.

BENCHOONA.

900 feet.

Hieracium anglicum, var. *iricum* (Fries.)—Mweelrea, 650. See un *H. anglicum*, at 2150.

NEPHINBEG RANGE (SCARDAUN LAKE).

860 feet.

Iris pseudacorus (Linn.)—Growing side by side with *Carex rigida*. startling coincidence. I know of no instance either of *Iris* occu ring nearly as high, or *Carex rigida* nearly as low. There wou usually be a gap of at least a thousand feet elevation betwe these two plants.

NEPHINBEG RANGE.

850 feet.

Eleocharis multicaulis (Sm.)—Mweelrea, 750; Birreencorragh, 60 Twelve Bens, 650. Especially abundant in the Connemara di trict, as in Glencoaghan.

MWEELREA.

850 feet.

Hypericum androsæmum (Linn.)—Twelve Bens, 420. Not unfrequen
Veronica officinalis (Linn.)—Common lower.

CROAGHPATRICK.

820 feet.

nagallis tenella (Linn.)—Ben Gorm, 800. Characteristic of the low-lying turf-bogs.

TWELVE BENS.

820 feet.

arex pallescens (Lam.)—Delphi Mt., 400; Mweelrea, 380 and 550. Very rare in the west.

ACHILL.

800 feet.

dum anglicum (Linn.)—Common at lower levels.

MWEELREA.

800 feet.

yrica gale (Linn.)—Delphi Mt., 770; Birreencorragh, 775; Maamtrasna, 750. Characteristic of the low turf-bogs and very rigorously defined in its ascent.

BIRREENCORRAGH.

775 feet.

lchemilla arvensis (Scop.)—Not seen elsewhere on the mountains.

MWEELREA.

750 feet.

osera anglica (Huds.)—Nephin, 500. Common in all the bogs below.

intermedia (Hayes)—Commoner than the other *Drosera*, especially in the wetter bogs about the margin of the big lakes, as at Derryclare and Inagh.

ubus fruticosus (Linn.)—Never occurs high up. This was, I believe, the variety *R. leucostachys* (Smith).

uercus robur (Linn.)—Twelve Bens, 700. Fine old native trees may be seen at the base of Nephin.

NEPHIN.

700 feet.

Chiefly usual lowland stragglers from this level.

Lychnis flos cuculi (Linn.)—White at 250 feet, Corslieve. Freq
Comarum palustre (Linn.)—Frequent.

TWELVE BENS.

650 feet.

Mentha aquatica (Linn.)—Not common in the mountain district.

MWEELREA.

650 feet.

Pinguicula lusitanica (Linn.)—Frequent to about this height.
Bunium flexuosum (With.)—Common.

CROAGHPATRICK.

630 feet.

Cotyledon umbilicus (Linn.)—Abundant below.
Scilla nutans (Sm.)—A lowland straggler.

CORSLIEVE.

600 feet.

Epilobium obscurum (Schreb.)—Specimens gathered near Delphi H in ditches by the road appeared to me to belong to typ *E. tetragonum* (Linn.). My plants were unfortunately b preserved.

NEPHIN.

500 feet.

† *Cratægus oxyacantha* (Linn.)—Perhaps introduced.

DELPHI MT.

500 feet.

Carex flava (Linn.)—Var. *œderi.* Not seen frequently.

MWEELREA.

480 feet.

osurus cristatus (Linn.)—Common.
fluitans (Scop.)—Common.

MWEELREA.

450 feet.

rinus excelsior (Linn.)—Handsome native trees occur in the "forest" at the base of Nephin.
ndo phragmites (Linn.)—Common.

BIRREENCORRAGH.

380 feet.

Cultivation at about 400 feet, the highest seen on the Mayo or Galway Mountains.

hemis nobilis (Linn.)—Not seen elsewhere; but this plant properly belongs to roadsides.
stis vulgaris (Linn.)—Var. *pumila*. Not seen elsewhere.

BIRREENCORRAGH.

350 feet.

phæa alba (Linn.)—Frequent.
ericum elodes (Linn.)—Frequent.
cularia intermedia (Hayne.)—Plentiful in many places, and occurs throughout the districts visited. Often, as by Glenlaur river and near Delphi House, it is found in the slimiest and filthiest mud-holes, where nothing else appears to thrive. I found it invariably (June and July) attached to its hybernacula. *See* Introduction.
caulon septangulare (With.)—Corslieve, 250. *See* Introduction.
pus fluitans (Hook.)—Plentiful in many places, as about Doo Lough and Derryclare.
chospora alba (Vahl.)—Corslieve, 250. Not common; but occurs in the wettest bogs in several places.
x filiformis (Linn.) }
mosa (Linn.) } The distribution of these species is given in the Introduction.

ACHILL.

350 (?) feet.

ntum capillus-veneris (Linn.)—Also, I believe, at Salrock.

MAAMTURK RANGE.

300 feet.

Cultivation at about 280 feet, Glencroft.

Nasturtium officinale (R. Br.)—Confined to the low ditches.
Carex paniculata (Linn.)—Frequent.
Lastræa oreopteris (Presl.)—Also on Letterbrickaun, ne Occurs very sparingly.

NEPHIN.

250 feet.

Cultivation at about 200 feet, Boughadoon.

Sanicula europæa (Linn.)—Frequent.

DELPHI MT.

250 feet.

Cultivation at about 230 feet, Glenlaur.

Rosa tomentosa (Sm.)—Less common than *R. canina*.
Stachys palustris (Linn.)—Common.
Habenaria chlorantha (Bab.)—Not unfrequent. *H. bifol* the base of Nephin.
Ceterach officinarum (Willd.)—Frequent.

CORSLIEVE.

250 feet.

Cultivation at about 200 feet, Deel Bridge.

ia minor (Linn.)—About the Killary in several places, but ngly and much scarcer in the districts visited than *U. inter-* ı.

is little cultivation at the bases of most of the mountains ı, and amongst the different ranges there are many extensive valleys whose botanical conditions are not influenced by the ıan. Several species are strictly confined to the bases of leys, although apparently all the conditions requisite for rth are fulfilled higher up. Some are, perhaps, denied the spreading, while, no doubt, a slightly decreasing mean tem-s we ascend drives many competitors from the struggle, and ace for the hardier sorts to thrive and monopolize the soil. e to obtain a list of these species, which are thus, though ready art, compelled to remain below. Plants of cultivation, or roadsides, broken soil, or habitations, do not enter this list, belonging to the immediate margin of the sea are also ex- All are, in fact, plants of a mountainous country, but con-ıe lowest levels.

ustris, Linn.
tea, Sm.
quadrangulum, Linn.
molle, Linn.
num, Linn.
us scoparius, Scop.
r, Scop.
munis, Huds.
num, Linn.
a, Linn. (*R. canina*, s.)
licaria, Linn.
ula, Linn.
tiana, Linn.
vulgaris, Linn.
m nodiflorum, Koeh.
ocata, Linn.
pulus, Linn.
rfara, Linn.
Bidens tripartita, Linn.
B. cernua, Linn.
Achillea ptarmica, Linn.
Gnaphalium uliginosum, Linn.
Centaurea nigra, Linn.
Hieracium pilosella, Linn.
Erica mediterranea, Linn.
Scrophularia nodosa, Linn.
S. aquatica, Linn.
Pedicularis palustris, Linn.
Veronica scutellata, Linn.
V. anagallis, Linn.
V. beccabunga, Linn.
Rumex conglomeratus, Murr
R. obtusifolius, Linn.
R. crispus, Linn.
Alnus glutinosa, Goert.
Habenaria albida, R. Br.
Allium ursinum, Linn.

Juncus lamprocarpus, Ehoh.
J. bufonius, Linn.
Sparganium ramosum, Huds.
S. natans, Linn.
Triglochin palustre, Linn.
Cladium mariscus, R. Br.
Scirpus savii, S. et M.
S. setaceus, Linn.
Carex remota, Linn.
C. ovalis, Good.
C. stricta, Good.
C. sylvatica, Huds.
C. præcox, Jacq.
C. hirta, Linn.
Arrhenatherum avenaceum, Be
Equisetum arvense, Linn.
Scolopendrium vulgare, Sm.

XII.—ON THE CRANIUM OF A NATIVE OF LORD HOWE'S ISLAND. By A. MACALISTER, M. D., F. R. S., Professor of Anatomy, University of Dublin.

[Read, December 11, 1882.]

ROUGH the kindness of Lowry Armstrong, Esq., of H. M. S. "Cor-rant," I have obtained the skull of a native of this very-little-own island. There are three islands of the south-east Pacific often founded with each other, and called by this name: the first of se, and the one to which I at present refer, is one of the Queen arlotte groups in S. lat., 11° 10′, East long. 165°, and is the next d to Egmont Island.

Another island of the same name, or, according to Captain Cook, et of islets united by a marginal reef, was described and first visited Wallis in 1767, in S. lat. 36° 50′, and E. long. 154° 21′, in the ion known as the Coral Sea; and yet another Lord Howe's Island east of New Ireland, of the Solomon group, in S. lat. 5° 30′, and ° 31′ E. long.

Less seems to be known of the first than of either of the others, no other cranium has as yet reached this country from it.

The skull in question is cryptozygous, and, to use the term invented the crania of the neighbouring race of New Caledonians, hypsi-ocephalic.[1] It was that of a young man, known during life to some he persons who had the opportunity of disinterring it some years r its burial. He was supposed to be about twenty-seven, but, from patent basi-occipito-sphenoidal suture, can scarcely have been so ; he is described as having been black and woolly-haired, as are others who inhabit the island. The bones are porous; the frontal ure is open for about a centimetre over the nose, but obliterated ve; the coronal suture presents the not uncommon character of ng nearly toothless for about 5 cm. on each side of the middle , then for about 3 cm. it is richly toothed, as far as the tem-al crest, while the lower 2½ cm. is again smooth.[2] The sagittal ure is accidentally slightly depressed in one place, and its denti-tions, slighter and simpler in front, are rich and complex behind. lambdoidal, also richly toothed, has one wormian bone on the t side near the top of the suture. There is a wormian bone at the of the left alisphenoid, directly below the line of the coronal, but occupying more than one-half of the long spheno-parietal suture, h measures 2 cm. The muscular crests are feebly developed; the small and rounded, but the impression for the splenius capitis usually distinct and flattened outwards, projecting against the oid process. The occipital condyles are unsymmetrical, the right g smaller than the left, and the margin of the foramen magnum is

[1] Barnard Davis, "Natuurk. Verhand. v. d. Hollandsche Maatschappij." Haar-xiv. deel.

[2] This character I have often seen; it is well marked in some Kanaka and n skulls in our Museum.

raised into a knob behind the right condyle. The right jugular hole is twice the size of the left; the styloid process is small; the mastoid large and thick, especially the left, as the right is a little flattened behind. The glenoid cavity is very much flattened, with scarcely any transverse ridge in front, and a very faint eminentia articularis. The foramen spinosum on the right is confluent with the spheno-petrosal suture. The pterygoid plate is not toothed, but the outer wall of the scaphoid fossa rises into a spur, and the external pterygoid plate has an upper spur for the upper form of the ligamentum pterygospinosum.[1] There is a strong crista verticalis on the anterior and outer part of the external pterygoid plate, in front of the pterygomaxillary fossa. The processus malaris of the maxilla rises along the front of the spheno-maxillary fissure, and almost excludes the malar from the margin. The malar has a well-marked masseteric crest, and the maxilla has a sutura infraorbitalis transversa, while the infraorbital hole is united to the brim of the orbit by the continuation of the fissure. The pre-lachrymal suture is nearly complete on the left, cutting off an accessory lachrymal, but is not so well marked on the right. The lachrymals have exceedingly sharp crests and deep grooves, but no hamuli. The nasals are narrow, separate, unsymmetrical, with foramina of Wenzel. The anterior nasal spine is sharp, the canine fossa deep, and the zygomatic ridges well marked. The alveolar arches are very large, the palate rather deep, the posterior nares narrow, oblique, the whole aspect of the pterygoid region being constricted at the basal attachment of the pterygoid processes. There is a supernumerary single-fanged tooth between the first and second premolar on the right side internally.

The measurements are as follows:—Length, 179mm.; greatest breadth, 137; frontal breadth, 104; circumference, 505; intermastoid arc, 400; fronto-occipital arc, 340; height, 149; orbital height, 32; orbital width, 37; nasal height, 49; nasal width, 24; basi-alveolar line, 108; basi-nasal line, 103; palato alveolar length, 62; palato-alveolar width, at last molar tooth, 66; palatine width, 38; width of both posterior nares, 21; height, 24; width of foramen magnum, 29; length, 33; length of spheno-parietal suture, 21. The lower jaw is large, with very little chin; external width at the angles being 105; at condyles, 115; at coronoid processes, 90. The left condyle is 21 long, the right 20; the sigmoid notch is 33 wide; the vertical height of the coronoid process is 64; the inner length of the intercondyloid intervals is 76; and the height at the chin is 32; while the whole length from angle to angle round the lower margin of the chin is 210. From these it will be seen that the altitudinal index is ·83: the latitudinal, much less, is ·76; the orbital, ·86; the nasal, ·48; the alveolo-nasal, ·104; the capacity measured by Busk's choremometer, 1350.

The cranium thus belongs to the type of hypsi-mesaticephalic leptorhine, mesoseme, prognathous, microcephalic skulls, and thus resembles in type the other Melanesians of neighbouring islands.

[1] See *Proceedings*, Royal Irish Academy, vol. ii. N. S., Science, p. 202.

XCIII.—FURTHER EVIDENCE AS TO THE EXISTENCE OF HORNED MEN IN AFRICA. By A. MACALISTER, M.D., F.R.S., Professor of Anatomy, University of Dublin. (Plate XX.)

[Read, December 11, 1882.]

SOME years ago Dr. H. Minchin lent me a photograph, brought home from West Africa by his son, the late Dr. R. Minchin, in which was pourtrayed the head of a West African, with two remarkable exostoses on the maxilla below the orbit. Dr. Minchin, junior, had stated with regard to this man that he had heard of a tribe having this peculiarity, that they were famous as executioners somewhere on the borders of Dahomey.

The peculiarity shown in the photograph (Pl. XX.) consists of two symmetrical, and evidently bony, outgrowths of the infra-orbital edge of the maxilla, in a long-faced and somewhat long-headed negro, with scanty moustache and beard.

I made many inquiries among those acquainted with the west coast of Africa, and though I found several persons who had heard something about the existence of people of the kind, yet I could get no satisfactory account until my friend, Dr. Allan, being appointed Colonial Surgeon at Bathurst, kindly undertook to make inquiries for me. One previous informant told me he had seen a man with spur-like processes on the malar bone, but could give me no definite information of his whereabouts.

Dr. Allan communicated with me that the man in question, whose photograph I had shown him, had come from Akim, in 6° North latitude and 1° East longitude. Dr. Allan obtained also from the late Captain O'Brien a letter, in which that gentleman related that he had made an attempt to get the man to Europe, but that having brought him to the seaport he repented, and could not be induced to go any further.

By the kindness of Professor O'Reilly I obtained an extract from a letter from his brother, H. F. O'Reilly, Esq., of Cape Coast Castle, in which he says:—"I examined the Kebby man six years ago, and subscribed £5 towards sending him home for examination. The history of that case is this. About six years ago Captain Hay (Houssas) was sent on a mission for the Government to a place called Kebby, I think, in the Diabbee country, north-east of Cape Coast. He there came across this man, and brought him down with him. We all agreed to send him home with Captain Baker, who was then starting for England. Baker took the fellow as far as Akim, where the steamer called; here the man cleared out, and was back in Cape Coast at my place in a few days. He told me that he could get no food on board, and so had run away. There is a bony exostosis on each malar bone over the antrum highmorianum. I was anxious to make a cast of the case at the time, but had no materials. From reasons of my own, and inquiries among well-informed natives, I came to the conclusion that the case was not a congenital malformation, but artificially produced, and that is the

reason I took so little interest in the matter. In fact I was told by some Fantees that it is quite possible to produce this deformity. As to there being a tribe of these men, or even a family similarly affected, that I very much doubt, as I think I must have heard something of it. Mr. Allan had seen this man from Kebby, and I believe he is in Akim country. I have seen plenty of tattooing here on the black skin, and as the pigment does not show well, they cause the granulations from the cut surface to rise from half an inch to an inch above the level of the skin. There would be no difficulty in causing a bony growth to spring from the antrum or from the malar bone by puncturing and applying the stimulants they use in tattooing. I am aware that the Akim country is thoroughly well known to a number of colonial officials, and they have not come across the horned men."

In the Verhandlungen of the Berlin Society for Anthropology, Ethnology, and Primitive History for 1877, an account of this man was noticed; but, from the remarks made by Professor Virchow, the outgrowth seems to have been confounded with one of the commoner pathological conditions of epidermal horn.

In the course of the last week I received from my friend, Dr. Allan, a second letter, dated from Gambia, November 17, 1882, in which he says:—"I enclose you a letter written to me by P. Hughes, Esq., Assistant Colonial Secretary at Sierra Leone. You will see from it that he confirms the certificate given to me by the late Captain O'Brien, and read by you to the Royal Irish Academy.

"Mr. Hughes further informed me, that while in Eastern Akim he saw two men with the horns, and the man described by Captain O'Brien. I think the existence of this peculiar family cannot be longer doubted. The horn is, I believe, an anatomical one, and not due to disease. The task of securing one of these skulls is, I am afraid, a hopeless one."

The letter referred to by Dr. Allan is as follows:—

"Sierra Leone,
"*November 13th*, 1882.

"Dear Sir,—In answer to your letter upon the subject of the horned man, described by Captain O'Brien, I beg to inform you that I have seen the man in question, and that Captain O'Brien's description of him is correct. This person was seen by Captain Hay in Akim in 1875 or 1876, and that officer made arrangements for sending him to England. I believe that he went on board the mail steamer, and then declined to proceed, and was, of course, allowed to return on shore. He was photographed, and copies can be obtained at Elmina, Gold Coast.

"When visiting Akim, in 1877, I observed two other men possessing, although in a much less degree, the peculiarities described in the certificate furnished to you by Captain O'Brien.

"I remain yours very truly,

"Percival Hughes,
"*Assistant Colonial Secretary.*"

The information thus gathered by the indefatigable researches of Dr. Allan is of very great interest. Exostoses, we know, are not at all uncommon in the vicinity of the antrum, and the one figured by Mr. Hilton (*Guy's Hosp. Reports*, vol. i.) is not unlike one of those shown n the photograph. A similar exostosis is described by Samuel Cooper n the *London Medical Gazette*, vol. iv., p. 369.

That outgrowths here may be really race characters is not to be ntirely ridiculed, for the neighbouring malar bone, which here, according to Dr. O'Reilly's description, participates in the swelling, certainly hows certain race peculiarities, such as the bigger *Tuberositas malaris* f the Mongolians, and the *Processus marginalis*, whose race peculiarities have been pointed out by Werfer (*Das Wangenbein des Menschen*, Tübingen, 1869); while Hilgendorf describes a separation of the malar into two parts as common among the Japanese (*Mittheilung. der deutschen Gesellschaft für Natur-und-Völkerkunde, Ostasiens*, 1873, p. 1). The examination of this region in the fifty African crania of our University Museum shows that while in one Congo negro there is a little fulness in this region, there is no trace of any enlargement in any of he others.

The Akim negroes speak a negro dialect of the Egwee class, and re of the same race as the Fantees and Ashantis, of which race I have everal crania, notices of which I hope to be able to lay before the Academy on a future occasion.

The letter formerly received from Dr. Allan is as follows:—

"MADEIRA,
"*February* 26*th*, 1881.

"DEAR DR. MACALISTER,—I send you a few lines relative to our onversation of 16th inst. I have learned a few authentic facts *en oyage* about the 'horned men' from Captain O'Brien of the Houssa Force, West Africa. The statement made here is certified below by im. A Captain Hay (now in Tobago, W. I.) had stated that he had een these men at Akim. We had one of the men *en route* for England, but he refused to proceed eventually. Captain O'Brien saw this man at Elmina, and describes him as follows:—'He was, as regards olour, hair, &c., similar to an ordinary native. The horns occupied he malar region, were about two inches in length, their direction eing, I believe, from his description, upwards, outwards and forwards, non-movable, and covered with skin.'"

The certificate of Captain O'Brien was as follows:—

"I certify I have seen a man answering to the above description xactly, and said to be the same person Captain L. Hay alluded to.

"PAUL D. O'BRIEN."

XCIV.—On the Crania of Natives of the Solomon Islands. By Alexander Macalister, M.D., F.R.S., Professor of Anatomy, University of Dublin.

[Read, January 22, 1883.]

The Solomon or Salamon Islands form a large Archipelago, about 700 miles long, made up of two lines of islands, whereof seven are of large size, and about thirty are smaller, and they form the easternmost portion of the Papuan Zoological Province. These islands are chiefly volcanic, margined with coral, well wooded, with a flora rich even for a western Pacific land; but they have from early times acquired for themselves an evil reputation, both in point of unhealthiness and inhospitality on the part of their inhabitants, and hence our knowledge of their ethnology is scanty and fragmentary.

They were discovered in 1668 by Meñdana, and since his time have been visited by Dumont D'Urville (*Voyage pittoresque autour du Monde*, 1835, vol. ii. p. 150); by Brenchley (*Jottings during the Cruise of H. M. S. Curacoa in* 1865: 1873, p. 248); by Redlich, master of the schooner "Franz" (*Journal Geographical Society*, 1874, p. 30); by Erskine in 1853; by Scherzer of the Austrian Expedition (*Novara-reise*, 1861. ii. 429); by Webster (*Last Cruise of the Wanderer*: Sydney, 1863). Inhabitants of these islands have been figured and described by Dumortier (*Atlas Du Voyage au Pole Sud.*), and by Virchow (*Verhand. der Berliner Gesellsch. f. Anthropologie, Ethnologie*, &c., 1877, p. 241). They have been also visited by my former pupils, Dr. Goode and Dr. Forbes, and two years since by H. M. S. "Cormorant," on the occasion of which visit these skulls were obtained by Lowry Armstrong, Esq., R.N., by whom they were presented to me.

There was (1873) but one European resident in the Archipelago, Mr. Perry, at Makira, San Christoval; but no mission station has hitherto taken root. Some years ago a Roman Catholic bishop and fifteen priests chartered a schooner and landed on Ysabel, but ere the prelate had been a few hours on shore he was murdered, and his companions compelled to re-embark (Erskine, *West Pacific Islands*, p. 335). My former pupil, Dr. Litton Forbes, who is well acquainted with the inhabitants of many of the Western Pacific Islands, thus characterises the Solomon islanders:—"So innately ferocious and bloodthirsty are the natives, that any white man that would live among them must go armed, unless, indeed, his object be martyrdom; otherwise, before he could possibly learn the languages and dialects of his congregation, he would, in mere self-defence, have to send so many souls to Hades,

that the subsequent success of years might not suffice to compensate the loss." Even when brought as labourers to Fiji, Dr. Forbes describes their condition as not much improved. In the work from which I have just quoted (*Two Years in Fiji*, p. 64.) he says, "All, however" (of the Polynesian labourers), "of whatever nationality, seem to regard the Solomon islanders with especial aversion, and even fear." From Dr. Forbes' experience of this transport Polynesian labour, he does not seem to regard it as such a potent civilizing influence for the island native as the late Anthony Trollope represents it to be in his work on *Australia and New Zealand* (vol. i. p. 133). These Solomon islanders, however, in Fiji, even after a short period of residence among others, have been known to steal, kill, cook, and eat any unfortunate people they might find straying near their huts. This cannibalism is habitual. Captain Redlich, of the schooner "Franz," saw a number of men who had cooked a captive whole, and then sold the body in parts, and on expressing his disgust to Mr. Perry, was informed by that gentleman that he had seen as many as twenty bodies cooked at one time for a single feast. Captain Redlich, however, says they seemed to him inoffensive when not excited. They keep the skulls of those whom they have eaten suspended in their canoe houses, along with other ornaments, such as the bones of fishes and curious wood carvings. Mr. Brenchley saw twenty-five such skulls in one place in San Christoval (at Wanga), all of which showed the effects of clubs or tomahawks. They do not seem, like the people of New Ireland, to hang the heads in their own huts. Mr. Brown (*Journal of the Royal Geographical Society*, vol. xlvii., 1877, p. 142) saw in one house in the latter island thirty-five human jawbones hanging from the rafters blackened with smoke: "a smoke-dried hand was hanging in the same house, and just outside I counted seventy-six notches in a cocoa tree, each notch of which the natives told us represented a human body which had been cooked and eaten there." These heads hung up in the canoe sheds have been for the most part robbed of their teeth, of which they make necklaces, such as the one I exhibit. These necklaces are not easily got. Commodore Sir W. Wiseman offered two guns for one and was refused. The late lamented Bishop Pattison, however, brought home three; and Dr. Goode obtained the specimen which is on the table from the island of Ulakua.

Scherzer says of these islanders that they were the most intractable and savage of all the tribes that he visited in the entire Novara voyage; and Brenchley describes them as being intensely excitable—stirred up to madness in a minute. It was here that Mr. Boyd, the owner of the "Wanderer," perished in 1862.

In appearance there is a great variety among the natives. Those of the inland parts of San Christoval, who live in the forest and on the slopes of the hills (which here rise to a height of 4000 feet), are called by the coast-dwelling natives Bushmen, and with these the fishermen, as they name the littoral tribes, are constantly at war.

The heads, consequently, which are found in the canoe houses are generally those of the Bushmen.

The people of San Christoval are said by Brenchley to be wretched, poor emaciated creatures, many of them covered with scaly eruptions, as though their skin was peeling off. This pityriasis is not rare among the Melanesians. Those of the inland districts are puny, but healthier looking. One native of Morrissi, examined by Virchow (*loc. cit.*), was a healthy, well-grown male of twenty; in height 5 ft. 2 in.; hypsi-brachycephalic, with a flat nose; strong, but not very prognathous jaws; skin of a dark blackish-brown colour; and beard black, thick, curly, short. Webster (*loc. cit.*) says they are nearly black, with woolly hair, and the countenance characteristic of the Papuan Negro. The males have the western Polynesian habit of stiffening their hair into mops, though not as largely as the Papuans, with yellowish clay and lime, which cosmetic they call *chinam* (cf. Strauch, *Zeitsch. f. Ethnologie*, vol. ix., 1877, p. 241).

The different islands have for the most part different dialects; and in San Christoval that of the fisher tribes (Bauro), which contain many Polynesian words, differs from that of the Bushmen, which is said to be more like the Ulana dialect.

San Christoval is the fifth largest of these islands, and the best known. The inhabitants are usually hung with ornaments, and wear heavy wooden and shell disks in their ears, sometimes lengthening the lobe considerably. This perhaps is correlated with the fact that in the second of our skulls the tympanic bone is much thickened. They almost all have transversely-placed rods or shells in their noses. They sometimes adorn their heads with handsome shell combs; sometimes they cut their hair in terraces from ear to ear. Mr. Brenchley saw some women who had their hair partially shaved off, or cut close, so as to leave a roadway across their heads. Many men are tattooed in patterns, produced by a series of short incisions, made with obsidian knives. Some of them have very flattened noses, but it does not appear that they increase this by art[1]. They chew betel, and are greedy for tobacco. They wear little or no clothing, and are exceedingly ingenious in their carvings and artistic work, illustrations of which are given by Brenchley. In the neighbouring island of Rubiana, near New Georgia, they prepare skulls as ornaments, colouring them with clay, fastening in artificial teeth of shell and wood, and mother-of-pearl eyes. Such crania are not, as far as I know, prepared or kept in the other islands of the group.

The crania available for comparison with my two are—one in the Hunterian Collection from Ysabel, and one from an island undetermined, presented by Sir Erasmus Wilson; as well as two artificially

[1] The new-born children of the island of Jap (Wuap), near the Pelews, have their noses squashed flat after birth by their parents. They call the operation "Andoweck": see Miklucho-Maclay, *Zeitschrift für Ethnologie*, x., p. 101.

prepared skulls from Rubiana, presented by Dr. Bennett; three described in the "Thesaurus Craniorum" from the Davis Collection from Makira, Christoval, brought home by Dr. Mac Gillivray of H. M. S. "Herald." One in the same collection from Guadalcanar; and one from Rubiana; as well as one in the Dublin College of Surgeons' Museum from Guadalcanar, for the measurements of which I am indebted to Mr. Abraham. Of these all but one are males; and the measurements I have given in the Table at the end (p. 780).

Skull No. 1 is that of a fisherman or Bauro, a phænozygous, hypsidolichocephalic cranium, microcephalic, platyrhine, micro-seme, prognathous, with very large everted alveolar arches; pentagonal in norma occipitalis. The sides of the foramen magnum have been broken; its hinder margin is, however, left at one spot; but the right side is cleanly cut away. The squama occipitis is symmetrically compressed immediately above and behind the asterion, and that region is tumid, especially on the left side. The mastoid process itself is small, but the whole mastoid portion of the temporal is dilated, and the paramastoid internal to the digastric groove is as prominent as the mastoid itself. The tympanic is very thick, especially below and behind; the basilar suture is closed; the occipital condyles unsymmetrical; the inion weak, rounded; the spheno-parietal suture is very short—4 mm. on right, 5 mm. on left; it is depressed on both sides, and placed very obliquely, rising forwards: the glenoid cavity is narrow; the outside of the external pterygoid plate on the left is prolonged into a small *processus pterygoideus tertius*, which margins the pterygo-maxillary fossa. The nasal bones are separate, narrow above, widening a little below, perforated by small foramina; the fronto-nasal sutures is above the fronto maxillary; the lachrymal has no hamulus, and there is a post-lachrymal and pre-ethmoidal constriction of the lachrymo-ethmoidal suture. There is a sutura infraorbitalis verticalis on both sides, to which the malar extends on the right side; and a deep canine fossa. There is an infraorbital eminence at the end of the malar on the right side; and the incisive portion of the alveolar arch is nearly horizontal. The greatest breadth of the arch at second molar tooth is 63 mm.; the palatine length is 46 mm.

Skull No. 2 is that of a Bushman, and it contrasts in many respects with the former; it is also a male, but is widely ovate in norma verticalis; nearly quadrilateral in norma occipitalis: it has a spear-wound above the lambda, and is very narrow in the forehead, 88 mm.; it is mesati-tapeino-cephalic, meso-cephalic, and was probably phænozygous, but has lost both zygomatic arches; it is also microseme, leptorhine, and prognathous, but without the prominent incisive arches of the former. The basilar suture is open, but the last molar on each side has been cut. The whole skull is flat-topped, with prominent parietal eminences, which are unsymmetrical, the right being very much farther back. The occiput also is more prominent backwards on the right than on the left side; the spheno-parietal

sutures are longer, not depressed—10mm. on left, 12 on right. The tympanic ring is thin: there is a posterior condyloid hole on the left; only a blind pit on the right, and a larger jugular hole on the right than on the left: the right external pterygoid plate is prolonged to the foramen ovale; the nasal bones are small, depressed, not dilating below. This skull, therefore, belonged to a young male, probably about twenty.

Dr. Abraham has kindly given me the following note concerning the skull from Guadalcanar, in the Museum of the College of Surgeons:—

"This specimen was presented to the Museum of the Royal College of Surgeons in Ireland by Staff-Surgeon P. Keelan, R.N. It was probably the cranium of a young male, as evidenced by the comparative thinness of the bones, the slight development of the muscular ridges and fossa, and the non-ankylosis of the sutures, especially in the case of the spheno-occipital. The teeth which remain in this specimen are, moreover, those of a young subject, with perfect crowns, and with the last molar on the left side not yet irrupted. The premolars, the left canine, and the incisors are wanting; the condition of the alveoli indicates that their extraction was *post mortem*. The upper canine of the right side presents a very remarkable abnormality, its growth being vertically upwards instead of downwards. The crown of the tooth is situated below the margin of the orbit, reaching above the level of the inferior orbital foramen. By pressure it has caused the absorption of part of the outer face of the superior maxilla, so that in the dry skull it has its outer enamel surface quite exposed. In the alveolar margin of the jaw there is no corresponding socket; and there is no evidence of a retained milk canine. The four functional teeth, which have been left in the upper jaw, are stained with betel nut. No lower jaw came with the specimen, having been, no doubt, disjointed and utilized as a bracelet. The basi- and ex-occipital portions of the base of the cranium have been knocked out, probably, as Dr. Keelan, in his letter accompanying the specimen, remarks, to get at the brain for cannibal purposes. From the serious wounds which are to be seen on the vault of the skull, and on the left temple, it appears that the individual must have required a great deal of killing. Dr. Keelan thinks it 'a case of death in fight from tomahawk wounds . . . the victim must have been in flight, closely followed. The sliced wound was probably first inflicted; next, the deep one near the vertex; the remainder—apparently down-cuts—when the victim had fallen to the earth on his right side.'

"In general configuration this cranium does not differ much from the long, rather narrow and high Melanesian type; but in certain points there seem to be considerable differences—for instance, in the nasal and orbital indices, as seen below.

"The principal measurements are :—

"Circumference,	500 mm.
Length (ophryon to occipital point),	178 ,,
Breadth[1] (interparietal),	134 ,,

Cephalic Index = 753, and therefore *sub-dolico-cephalic.*

Nasal height,	48 mm.
Nasal width,	22 ,,

Nasal Index = 458, and therefore *leptorhine.*

Orbital width,	37 mm.
Orbital height,	35 ,,

Orbital Index = 946, and therefore *megaseme.*

"In consequence of the absence of the base of the skull, neither the Capacity, the Alveolar Index, nor the Height Index, could be accurately measured. An approximate estimate, however, for the Height Index would give 770 as the number. Although no attempt could be made to determine the Alveolar Index, it is very evident that the face was prognathous."

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[1] The inter-temporal breadth is the same.

TABLE OF MEASUREMENTS OF CRANIA OF SOLOMON ISLANDERS.

	Capacity.	Circumference.	Length.	Breadth.	Height.	Intermastoid Arc.	Fronto-Occipital Arc Frontal.	Parietal.	Occipital.	Orbital Height.	Orbital Width.	Nasal Height.	Nasal Width.	Basi-Alveolar Line.	Basi-Nasal Line.	Breadth Index.	Height Index.	Orbital Index.	Alveolar Index.	Nasal Index.
No. 1, T.C.D., ...	1175	470	168	120	126	342	120	130	84	31	38	42	23	93	89	714	750	795	1045	548
No. 2, T.C.D., ...	1360	494	178	130	130	365	124	126	102	30	40	46	22	99	98	775	730	750	1010	478
Ysabel (Flower), ...	1450	505	180	135	136	—	—	—	—	35	42	53	24	104	100	750	756	833	1040	453
Solomon Islands (Flower),	—	503	182	132	139	—	—	—	—	32	36	50	23	96	101	725	764	889	950	460
Christoval (Davis), ...	1456*	507	182	122	130	362	120	135	110	—	—	—	—	—	—	670	710	—	—	—
Christoval (Davis), ...	1325*	490	170	135	135	375	115	117	120	—	—	—	—	—	—	790	770	—	—	—
Christoval (Davis), ...	1410*	495	178	125	140	350	120	140	107	—	—	—	—	—	—	700	780	—	—	—
Guadalcanar (Davis), . .	1475*	502	180	130	140	355	117	130	—	—	—	—	—	—	—	720	770	—	—	—
Guadalcanar (R.C.S.I.), .	—	500	178	134	—	—	—	—	—	35	37	48	22	—	—	754	—	946	—	—

V.—ON THE MORPHOLOGY OF JOINTS. (PART FIRST.) By ALEX. MACALISTER, M.D., F.R.S., Professor of Anatomy, University of Dublin.

[Read, February 26, 1883.]

most of the systematic treatises on Human Anatomy the descrip- s of the articulations are usually defective and unsatisfactory. importance of these structures from a surgical point of view ed the anatomists of the end of the last and early years of this ury to devote much care to their investigation, and subsequent ribers have for the most part been content to follow the accounts Veitbrecht, Bell, the Coopers, Cloquet, and their contemporaries.

As a consequence of this, the morphological relations of the struc- entering into the joints have been largely disregarded, and their omy is described from the strictly utilitarian, and not from the tific, point of view.

The method followed in the dissections of the joints hinders our nition of the real nature of these parts. In general all the teral parts are cut away before the ligaments are considered, and e bands are often described as substantive ligaments which are y deeper attachments of superficial parts.

n the course of a careful series of researches, carried on for the ose of verifying in detail the materials accumulated by me for a matic treatise on Human Anatomy, I have been much impressed he unsatisfactoriness of the state of our knowledge of the mor- ogical anatomy of joints, and I shall, therefore, in this communi- n, and in those that follow it, endeavour to contribute to the ring of some of this obscurity. Much of what I shall have to ribe is, I doubt not, very well known to those engaged in practical omical work, but has not hitherto been put on record.

I have endeavoured to determine the history of the individual ts by the twofold method of embryology and ontology, and in this er I desire to summarize some of the general results of my studies.

The embryological history of the larger limb-joints in man may be med up thus:—At first, on the appearance of the limb, the axis or thereof consists of undifferentiated mesoblastic cells. In this cen- mesoblast a process of chondrification commences in the areas rein the several bones are afterwards to be. In this state are the s of the smallest embryo examined by me, one of 2½ cm. long. This sformation begins in limited, nearly central spots, and spreads until sults in the formation of a discontinuous chain of cartilages in the of the limb, each cartilage corresponding in place to the bone into h it is about to develop. The end of each of these is attached to ontiguous end of its neighbour by a mass of embryonic connective e which fills up the interspace, and which is similar in structure e primitive unchondrified axis, and to the investing layer, which

still remains surrounding the cartilage. This intervening material ties the cartilages together, constituting a series of syndesmoses, or more correctly (for the intervening substance is not ligament), of joints of the type which Professor Hyrtl has called Agonarthrosis.

The ends of the cartilaginous rods swell, and assume somewhat of what is to be their permanent shape, and in doing so they grow towards each other, in which process the disks of connective tissue intervening between the contiguous ends become thinned in the middle, and finally they disappear in the centre, and the cartilages come in contact with each other, the fissure between the two, where the central disk has disappeared, being the primary cavity of the joint. The connective disk still remains peripherally, but in most joints gradually vanishes from the region between the articular ends, remaining as a continuous girdle of connective tissue around the joint in the form of a capsular ligament, This becomes white fibrous tissue, as does the most of the layer on the surface of the shaft of the cartilage with which this is continuous, and which is now perichondrium.

The chronology of these changes is not easily settled. In an embryo of 3·8 centimeters long the central cavity has begun to appear. In one of 5·6 cm. the cavities are formed and the ligaments are embryonic fibrillar tissue; in a fœtus of the thirteenth week many of the permanent conditions are present.

In such joints as are about to develop inter-articular cartilages, the intervening embryonic connective disks, instead of disappearing, solidify, and much later chondrify, and clefts form on both surfaces between these as substantive elements and the ends of the bones. This, we shall see, is the history of the sterno-clavicular joint. In joints which have partial disks like the menisci of the knee, these are derived from the persistence of the later stage of partial absorption.

The hip-joint in man is developed earlier than the knee; the shoulder and knee develop about the same time; the elbow and ankle are usually in the same condition in the same embryo.

In the joints of adults we find that the ligaments are naturally classifiable, according to their origin, into four groups:—

1st. Those derived from the primitive capsule whose origin we have just traced, and which are consequently continuous with the periosteum. These are the true ligaments of all joints.

2ndly. Those derived from the tendons of muscles which surround joints; thus much of the internal lateral ligament of the knee is derived from material continuous with the tendon of the adductor magnus, and much of the posterior ligament from the semi-membranosus.

3rdly. Those derived from fasciæ. In the primitive development of the limb the bundles of muscle are surrounded by embryonic connective tissue, which, as the muscles become specialized, forms a fibrous sheath around each: these combined sheaths uniting, and fastened together by the circular fibres developed in the deep subcutaneous and sub-adipose layers, form the system of limb-fasciæ and intermus-

pta. Where these partitions dip in and come in contact with sules of joints they adhere thereto, and form a series of accesaments; thus the pubo-femoral accessory ligament of the hip ed by the pectineal portion of the fascia lata, and the sciatic ts are genetically connected with the inferior involution of the fascia.

y. Those derived from degenerated muscles. Of these, in man e representatives in the intercostal expansion in front of the l intercostal muscle, and in the posterior sacro-coccygeal ligaut in lower animals, as in the horse's foot, we find a striking .

articular cavities are primarily limited to the spaces between s of the bones; but, secondarily, from the formation of bursæ, m the communication of these with the joints, the cavity extended. The shoulder and the subscapular bursa is an illustration.

ecial case of such enlargement occurs in the knee-joint, which ar in its development, as I shall have opportunity of showing on occasion when describing my sections. The femoral condyles h the tibia, each independently, and two independent cavities are between which a ridge of the primitive embryonic disk becomes med into fibrillar tissue, forming the crucial ligaments; while gins of the original inter-articular discs persist as the menisci. sule originally flows around the joint close to these, and the all lie external thereto. In the quadriceps tendon a sesamoid develops (the patella), between which and the front of the there forms a large bursal cavity, under which the front wall roper capsule becomes deficient, its shreds persisting as the ligament, and the alar ligaments, and the Haversian pellet of many animals the tendon of the extensor digitorum arising femur passes down in front of the joint under the quadriceps. rog this is in front of the anterior wall of the capsule; but in the wall is deficient behind it, and so it passes free through t, as it does in so many other animals.

he second part of this Paper I purpose entering into detailed ions of the histories of the individual articulations.

XCVI.—Report on the Entomology of certain Districts in Ulster.

By W. F. De V. Kane, M. A.

[Read, February 26, 1883.]

The problems presented by the distribution of the Entomological Fauna of the British Islands are not less interesting than the similar ones which have engaged the attention of scientific botanists; but owing to the neglect of the former study in Ireland, researches that should have proceeded hand in hand, and thrown mutual light on each other, have been almost exclusively carried on by students of the latter branch of Natural History.

It is true that no certain conclusion can be drawn from the occurrence in this country of such insects as are capable of swift or long-sustained flight, as necessarily indicating a former connexion by land with Great Britain or France, such as Geological evidences point to. But among the order of Heterocera (or moths) are numbers whose females could not have flown across the Channel, some of them being apterous, and others of very feeble powers of flight, or with very local or sluggish habits.

The unaccountable ill success, moreover, which has hitherto attended the efforts of many of our best Entomologists to introduce new species perfectly suitable, in every respect, to new habitats where their food-plant naturally abounds, deepens the obscurity of the problem.

Some able Papers comparing the Irish with the Scotch Entomological fauna (striking similarities between some of which were indicated by Mr. Birchall) have been written by Dr. Buchanan White, of Perth; but they deal with Diurnal Lepidoptera exclusively, which, although our prevailing strong winds are from the S. W., may many of them be credited with having crossed the Channel by flight.

Since, therefore, careful and systematic investigations of our really indigenous Lepidoptera may lead to very interesting conclusions, I venture to suggest some directions in which Irish Entomologists might well labour, so that reliable data may be available for scientific inquiry.

In the first place it is, above all, necessary that the Catalogue of Irish Lepidoptera, compiled by the Rev. Joseph Greene, and subsequently largely added to by Mr. Birchall, should be thoroughly revised, so that no name may appear of any species, the capture and locality of which has not been vouched for either by one of these gentlemen, or some other competent and reliable Entomologist.

In the second place, it would be most advisable that fresh ground should be worked, for hitherto collectors have confined their attention almost exclusively to Killarney, the counties of Dublin and Wicklow, and parts of Westmeath, Galway, and Mayo.

Thus the long reaches of sand-hills or rocky shores around our coasts, luxuriant with every sort of maritime plant, and exposed to various aspects and climatic conditions, have for the most part yet to be explored. Our vast bogs, and numerous lake and river margins, though as yet undisturbed by the intrusion, as in the sister island, of populous towns and manufacturing settlements, have, strange to say, contributed a more meagre list of marsh insects than any one of the English fen districts. And although the woodlands of Killarney and Powerscourt have yielded surprising results to Mr. Birchall and others, yet we may reasonably hope for numerous fresh discoveries in like districts elsewhere in Ireland. For although we have no such treasury of Natural History as the New Forest in Hampshire, yet we should not forget that this country was far more recently than England clothed with dense forests and wild scrub-lands, large tracts of which survived as late as the year 1700.

We may, therefore, reasonably expect to find, wherever traces of any such forest lands still exist, the relics of a formerly abundant entomological fauna.

The objection usually urged, that the damp climate of this country is prejudicial to the multiplication of Lepidoptera, is only valid as regards the sun-loving diurnal Rhopalocera, which swarm even in subarctic regions, however cold and long the winter, provided only the summer is brilliant with sunshine. My report deals with the Macro-Lepidoptera observed in two districts where portions of old forest still survive; but as these remnants are yearly disappearing, or being replanted by more profitable species of timber, I propose, if the subject is thought worthy of the attention of the Academy, to indicate in a future Paper some localities of a like nature which still exist in each province of Ireland, and which might, if examined, contribute new botanic and entomological discoveries. I shall now pass on to give an account of the places explored, but cannot help referring to the loss I sustained in being deprived by the hand of death of the assistance of the accomplished young student of Natural History with whom I was to have been associated; namely, the late F. W. Sinclair. I had but just sketched out the plan of our proposed operations when a fatal illness hurried him to the grave, followed by the hearty regrets of all his friends and acquaintances. These furnished an eloquent testimony to his worth and promise. He left but scanty entomological memoranda, so that much of his experience is lost.

It seems regrettable that no Society exists in this University City, as elsewhere, which would gather together lovers of Natural History such as he, record their researches, and through its members diffuse throughout the country an interest in these humanizing studies.

The districts I examined lie in Ulster, which being for the most part devoid of woods, and devoted chiefly to tillage, has hitherto proved the most unfruitful province to the Entomologist. Although my labours were not ill rewarded, as the appended list of 225 species will show, yet it was unfortunate that the past season has been

throughout the United Kingdom the most barren of entomological results that has occurred for many years.

The preceding winter having been exceptionally mild, while the summer of 1880 (which proved exceedingly prolific of Lepidoptera) succeeded an intensely cold winter, furnished a problem for Naturalists which attracted considerable attention. A careful analysis of reports and observations from various parts of Great Britain, coupled with my own experience, has led me to the conclusion that the scarcity has been most marked in such species as have arborivorous larvæ, and (in certain exposed localities) among those whose food-plant, though low-growing, is fragile, and easily destroyed by wind. I, therefore, conclude that the storms of the summer and autumn of 1881 must have shaken many tree-feeding larvæ from their food, and in certain situations destroyed the foliage of many herbaceous plants, especially on the sea-coast. The mild winter, no doubt, was a factor in the problem, for in such weather slugs, woodlice, and beetles, are more active in their ravages upon such pupæ as are not protected by a stout cocoon, or deeply buried beneath the soil; while on the other hand neither ova nor pupæ have their vitality at all affected by intense frost. My researches were commenced in March last at Favour Royal, the seat of the Rev. J. J. Moutray. This demesne, situate on the border of the county Tyrone, was formerly part of a thick covert of oak, birch, ash, alder, and elm, of some four or five miles in length, which is marked as a wood in some maps of the 17th century. Its original extent can be pretty clearly traced in the designations of the townlands about, some thirty of which commence with the prefix of "Derry," or "Killy." Of this stretch of woodland, to which, doubtless, the old Irish air "The green woods of Truagh" refers, portions consisting of about 220 acres are still preserved in the demesne of Favour Royal and the contiguous woods of Gallagh, Creaghan, and Lismore; while the Deer-park encloses about 180 acres of wild land, sparcely timbered with oak, birch, and alder. The oak and ash now standing of these woods are saplings sprung from stools of trees felled a century or more ago, while birch and alder spring up thickly in every clearing; and holly, hazle, and blackthorn furnish a dense undergrowth throughout.

These thickets, invested with the glamour of a hoar antiquity, are supposed still to be the haunt of the "Loghrie-man" or "Leprechaun," whose wizened face peering out from a mossy stump is said sometimes to startle the lonely scollop-cutter as he bends to his task in the gloom of the wood; and also of an unseen sprite, whose attendant foot-fall, stirring the dead leaves in the autumn gloaming, is wont to mock his homeward steps. About a mile and a-half away is a wild glen called Altadiawol, often referred to by Carleton in his *Traits and Stories of the Irish Peasantry*. This glen runs up into the spurs of the Slieve Beagh hills, and is clothed with thick scrub, while birch, oak, ash, and alder, straggle up the slopes, and hang from the precipitous heights on either hand.

To this, though a promising locality, I was unable to devote much time; for, owing to the unsettled state of the country, I found my nocturnal rambles there were generally superintended by two stalwart members of the Royal Irish Constabulary.

Enthusiasm in so peaceful a pursuit as mine is somewhat chilled by such ominous concomitants.

Thrice in the year I spent a week or a fortnight in that neighbourhood, proceeding from thence to Lough Oughter, where, by the kind permission of Lord Farnham, I was lodged in a "cottage ornée" on the promontory of Killykeen (beautiful wood), an appellation it well merits. The shores and islands of this lake are still partly clothed with remnants of the ancient woods which have given them in many cases their names.

The same descriptions of timber are found here as at Favour Royal, while the underwood is a dense thicket of hazle. Not only were the shores of Lough Oughter anciently wooded, but the west bank of the river Erne, down to its junction with the upper lake of that name, is marked in the old maps as having been a forest.

In this district I was fortunate enough to secure a large variety of species in the early season, some in great numbers, and others of much rarity. The later season I devoted to the examination of the neighbouring demesne of Farnham, which, from its extent and the magnificence of its timber, promised remarkable results.

But from the reasons above alluded to, aided by inclement weather, I took very few species of any kind there, even *Scopelosomia satellitia* being conspicuous by its absence, and only a single specimen of *Agriopis aprilina* occurred, in a demesne full of magnificent oak!

From both localities, however, I have hopes of future additional results from my visits, as I have furnished apparatus to very intelligent persons, who are instructed in their use.

The manor of "Farnane," as it is designated in the Down Survey, *i.e.* "the place of alders," was acquired by an ancestor of the present earl some 230 years ago, when the extensive beech woods, now of colossal size, were most likely planted, and are said to have been the first introduced into Ireland. It is probable that some of the great oaks may date beyond that period, and be survivals of ancient woods which formerly clothed part of that country.

These two localities are very similar in their geological and botanical features, but differ somewhat in elevation, the Favour Royal district averaging about 300 ft., while L. Oughter is 160 ft. above the sea level at low-water. The former is situated at the tongue of the Tyrone coal measures, just at the junction of the Carboniferous and Old Sandstone series; while the latter, Farnham, forms part of the central Limestone plain of Ireland. Though separated by about twenty-five miles of country, very bare of trees, the accordance of their entomological fauna is remarkable, as a glance at the list will show, and this would, doubtless, be more evidenced by further careful research, and would seem to indicate a formerly widespread distribution, several

of the species not having been hitherto met with nearer than Killarney or Wicklow.

The following are some of my most interesting captures, many of them having been recorded only once before in Ireland, and the first three are quite new to our list.

(F. R., *Favour Royal*; F., *Farnham*) :—

Hypsipetes ruberata, F. R.
Emmelesia affinitata, F. R. and F.
Acentropus niveus (Pyralidæ), F.
Hypsipetes impluviata, F. R. and F.
Numeria pulveraria, ,, ,,
Lobophora hexapterata, ,, ,,
Lobophora viretata, F.
Lobophora lobulata, F. R.
Ptilodontis palpina, F.
Cymatóphora duplaris, F. R. and F.
Cymatóphora or, F.
Xylophasia hepatica, F.
Taeniocampa gracilis, F. R.
Biston hirtaria, F.
Nola cristulalis, F. R.
Miana arcuosa, F. R. and F., and several others.

The specimens taken quite confirm the observation of Mr. Birchall, that our Irish Heterocera are frequently characterized by more striking pencilling and brighter colouring than those of England. Whether this proceeds from insular variation, or heredity, is a question which the formation of a good Irish collection might cast some light upon. And it appears to me that a comparison of a good series of our insects, which have apterous females, with those of the Continent would afford some approximation to a test of variation; seeing that their introduction hither must, with little doubt, have taken place at an enormously remote period.

Among the sun-loving Rhopalocera, southern latitudes or warm situations produce brighter colouration, and as we approach sub-arctic regions or higher mountain altitudes paler colours and blurred delineation characterize the specimens. With the Heterocera, however, the contrary, to a certain extent, seems to obtain. Some variations of interest occurred at both localities. The variety "combusta" of *Xylophasia rurea* was somewhat abundant; and at Farnham I took two specimens of the ab. Gallicus (Lederer) of *Hepialus velleda*. The type of *Melanippe montanata*, taken in Shetland (var. Hethlandica), seems identical with some taken at Farnham.

A LIST OF LEPIDOPTERA,

during the year 1882, *at Farnham and its neighbourhood, County Cavan; and the District about Favour Royal, County Tyrone.*

VIATIONS USED:—F., *Farnham*; F. R., *Favour Royal* (where no locality appended, the insect has been taken at both places): ab., *abundant*; v. ab., *ry abundant.*

DIURNI.

brassicæ.
pæ.
pi.
ocaris cardamines, v. ab.
nnis paphia, ab.
sa urticæ, ab.
alanta, F. R.
rdui, F. R.
Satyrus (Pyrarga) ægeria, v. ab.
S. (Pyrarga) megæra.
Epinephile janira.
E. hyperanthus.
Cœnonympha pamphilus.
Lycæna icarus (alexis).
L. argiolus, ab., F. R.

SPHINGIDÆ.

ocampa elpenor.
oglossa stellatarum.
Macroglossa bombyliformis, F. R., locally ab.

NOCTURNI.

alus velleda.
lleda, ab., *gallicus (Lr.)*
muli.
is (Ino) statices, F. R., locally
na filipendulæ.
cristulalis, F. R.
Nudaria mundana, F.
Euchelia jacobæ, v. ab.
Chelonia caja, ab.
Arctia lubricipeda,
A. menthrasti.
Demas coryli.
Pœcilocampa populi, F. R.

GEOMETRÆ.

teryx sambucata, F.
e apiciaria.
a cratægata, ab.
campa margaritata.
illunaria, v. ab.
opera bidentata, v. ab.
llis elinguaria, F. R.
ra pennaria, ab.
Biston hirtaria, F.
Boarmia repandata.
Tephrosia crepuscularia.
T. biundularia.
Pseudoterpna cytisaria.
Geometra papilionaria.
Iodis lactearia, not scarce.
Acidalia scutulata, ab.

A. bisetata, locally ab.
Cabera pusaria, v. ab.
C. exanthemaria, v. ab.
Strenia clathrata, F. R.
Numeria pulveraria.
Fidonia carbonaria, F. R.
F. atomaria, F. R.
Abraxis grossulariata.
Lomaspilis marginata, F. ab. at F. R.
Hybernia aurantiaria, F. R.
Anisopteryx æscularia, ab.
Chimatobia boreata, ab.
Oporabia dilutata, ab.
Larentia cæsiata, F. R.
Emmelesia affinitata.
Em. albulata, ab.
Eupithecia abbreviata, F. R.
E. satyrata, F. R.
E. subnotata, F. R.
E. vulgata.
E. tenuiata.
E. exiguata, F. R.
Lobophora hexapterata.
L. viretata, F.
L. lobulata.
Thera simulata, F. R.
Hypsipetes ruberata, F. R.
H. elutata, ab.
Melanthia rubiginata, ab.
M. subtristata, ab.
M. montanata, v. ab.
M. galiata.
M. fluctuata.
Anticlea badiata, ab.
A. derivata, F. R.
Coremia propugnata, F. R.
C. ferrugata, ab.
C. unidentaria.
Camptogramma bilineata, ab.
Phibalapteryx lignata.
Cidaria psittacata, not scarce.
C. corylata.
C. russata, ab.
C. immanata, v. ab.
C. suffumata.
C. silaceata, F. R., ab. at F.
C. testata, F.
C. populata, F. R.
Pelurga comitata.
Eubolia mensuraria.
Anaitis plagiata.

DREPANULÆ.

Platypteryx lacertula, F. R.
Platypteryx falcula, F. R.

PSEUDO BOMBYCES.

Dicranura bifida, F.
Ptilodontis palpina, F.

NOCTUÆ.

Thyatira derasa.
T. batis, F. R., v. ab. at F.
Cymatophora duplaris.
Cym. or, F.
Acronyctia psi.
A. rumicis.
Leucania comma.
L. impura, ab.
L. pallens, ab.
Nonagria fulva.
Hydræcia nictitans, ab.
H. micacea, ab.
Xylophasia rurea, v. ab.
Var. *combusta*, not rare at F.
X. lithoxylea.
X. sublustris, F. R.
X. polyodon, ab.
X. hepatica, not rare at F.
Charæas graminis, ab.
Luperina testacea, F.
Mamestra brassicæ.
Apamea basilinea, v. ab.
A. gemina, ab.
A. fibrosa, not scarce.

, ab.
F. R.
'inea, ab. at F.
da, F.
v. ab.
, F. R.
is, ab.
ina, F.
.
F. R.
'. R.
F.
R.
R.
ia.
thica, v. ab.
.
o.
R.
R.
ab.
. ab.

Anchocelis lunosa, ab.
Cerastis vaccinii.
C. spadicea.
Scopelosoma satellitia.
Xanthia silago, F. R.
X. ferruginea, ab.
Dianthœcia cucubali, F. ab.
Polia chi.
Miselia oxyacanthæ, ab.
Agriopis aprilina, F.
Phlogophora meticulosa, ab.
Euplexia lucipara.
Aplecta herbida, not scarce.
A. nebulosa, "
Hadena adusta.
H. dentina.
H. oleracea, ab.
H. pisi.
H. thalassina, ab.
Xylocampa lithoriza, F. R.
Calocampa vetusta, F. R.
Xylina rhizolitha F.
X. petrificata, F. R.
Abrostola triplasia F.
Plusia chrysitis.
P. gamma, ab.
Gonoptera libatrix, v. ab.
Amphipyra tragopogonis, F. R.
Euclidia mi, F. R.

DELTOIDS.

's, F.

Herminia cribralis.

PYRALIDES.

ialis.
uralis.
. R.
lis.
ialis, F.
tiotalis, F.
mphealis, F.
eus, F.

Botys fuscalis.
B. terrealis, F. R.
Pionea forficalis, F.
P. stramentalis, F.
Scopula olivalis, F.
S. prunalis, F.
Scoparia ambigualis.

CRAMBITES.

'lus, F. R.
F. R.

Crambus tristellus, F.
C. hortuellus, F. R.

C. musculana, F. R.

PTEROPHORI.

Pterophorus ochrodactylus, F.
Pt. plagiodactylus, F.

Pterophorus monodacty

XCVII.—SUGGESTIONS ON THE DEVELOPMENT OF THE CYCLIC LAW OF THE CHEMICAL ELEMENTS. By THOMAS BAYLEY, Assoc. R.C.Sc.I. (Plate XXI.)

[Read, February 26, 1883.]

IN a paper published in the *Philosophical Magazine*, Jan., 1882, in discussing the law, originated by Newlands, and called by him the law of octaves, and subsequently developed by Mendelejeff and L. Meyer under the name of the periodic law, the author pointed out that "the increments of atomic weight which, starting from hydrogen, successively give the points where the atomic volume is a minimum are members of the geometric series (see note, p. 795):

$$a,\ a \times b,\ a \times b_2,\ a \times b_3\ .\ .\ .\ a \times b_n,$$

where $a = 10$, and $b = \frac{10}{6}$."

In the same Paper it was shown that the colour properties of the elements when associated as bases with colourless acids are periodic, the metals in the first and second cycles forming no coloured solutions, and in succeeding cycles those metals only forming coloured solutions which occupy the region of low atomic volume. In accordance with this fact, it was argued that uranium, which is a metal having strongly coloured solutions, a high melting point, and great density, must occupy the mediate position in a cycle, and the atomic weight, 180, was suggested as probable because agreeing with these conditions. Since the Paper was written, however, investigation of the density of uranium tetrachloride and tetrabromide by Zimmermann has shown that the atomic weight of uranium cannot be less than 240, and other researches—that of Setterberg on caesium and that of Nilson on thorinum in particular—have afforded material for the further development of the cyclic law.

The successive terms of the geometric series

$$a,\ a \times b,\ a \times b_2,\ a \times b_3\ .\ .\ .\ a \times b_n,$$

where $a = 10$ and $b = \frac{10}{6}$, are

10, 16·6, 27·5, 45·7, 75·9, 126·0,

and the atomic weights are

11, 27·6, 55·1, 100·8, 176·7, 302·7.

It is therefore probable that the sixth cycle attains to its minimum of atomic volume in the neighbourhood of the atomic weight 300. The progression of atomic weight in the first two cycles is 16, and in the second and third approximately three times sixteen, or 46·4 and 47·5

respectively. Assuming that a similar simple ratio holds good in the progressions of atomic weight that constitute the cycles higher than the fourth, the progression from caesium to the element at the head of the sixth cycle is probably six times sixteen, or about 96, which makes the atomic weight of this element about 226. We may, therefore, anticipate the future discovery of an alkali metal having approximately this atomic weight. Such an element would have a density of 2·5 or thereabouts, and a corresponding atomic volume of about 90. Its melting point would be low, and its chemical affinities intense, and, as is the case with caesium, the metal probably would not be reduced by ignition of the carbonate to whiteness with charcoal. Granting the existence of this element and of a halogen analogous to iodine, the fifth cycle is terminated, and thorinum and uranium form part of the sixth. This implies the existence of an alkaline earth metal with atomic weight about 230, and of an earth metal analogous to Sc and Yt to precede thorinum. Thus:

Rb,	Cs,	Alkali metal.
Sr,	Ba,	Alkaline earth metal.
Yt,	—	Earth metal.
Zr,	—	Th.

Thorinum and uranium thus come within the earth region of the sixth cycle, and the coloured solutions of uranium are normal phenomena falling under the law of atomic volume.

The platinoid metals of the sixth cycle probably closely resemble their atom analogues of the fifth, and also have close lateral affinities with each other. Judging by analogy, we may expect to find these higher platinoid metals associated in small quantities with their lower atom analogues, and to experience considerable difficulty in separating them from the latter. Their unsuspected presence in iridium and osmium may possibly account for the upward displacement of these metals in the fifth cycle. In the same way the presence of a higher atom analogue of tellurium (atomic weight about 214) may account for the distortion of the fourth cycle by this element.

Brauner has recently examined the oxides of the metals lanthanum, cerium, and didymium, and has assigned to these elements the positions in the fifth cycle respectively analogous to the elements yttrium, zirconum, and niobium in the fourth. That this is the true sequence and atom analogy of the cerite metals now admits of little doubt, but, at the same time, the progression from yttrium to niobium constitutes a far larger portion of the fourth cycle than the progression from cerium to didymium does of the fifth. The cerite metals all occupy the earth position in the fifth cycle, and in their general properties are elements of the pure earth type, and, as such, strictly analogous to aluminum; and facts thus justify L. Meyer's conception that all three are analogues of the earth elements. They may be said to be cycle analogues of aluminium; and the series analogues of yttrium, zirconium, and

niobium respectively, as shown by Brauner, by the study of their oxides and other compounds and the sequence of their atomic weights.

The space between didymium and the platinum group, occupied with certainty according to our present knowledge only by tantalum and tungsten, is still a *terra incognita* requiring exploration. Erbium may be a member of a second series in the cycle, and tantalum and tungsten higher members of the same period. The determination of the specific heat of erbium and its associates, or, failing this, of the densities of some of their most volatile compounds, would be, at the present time, an important increment of chemical knowledge, as throwing light upon the constitution of the fifth and, by analogy, the sixth cycles.

If this second period exists, and fills up the gap between the cerite and platinum groups, the fifth and sixth cycles probably contain three primary septenary series, and the comparison of dimensions between the various successive cycles is as follows:—

Terms of the geometric series $a, a \times b, a \times b^2 \ldots a \times b^n$—

$$10, \frac{100}{6}, \frac{1000}{36}, \frac{10000}{216}, \frac{100000}{1296}.$$

The progression between successive alkali metals—

$$16, 16, 3 \times 16, 3 \times 16, 6 \times 16, (6 \times 16).$$

The number of primary septenary series in the cycle—

$$1, 1, 2, 2, (3), (3).$$

The diagram on Plate XXI. shows the dimensions of the fifth and sixth cycles in accordance with the suggestions made in this Paper. The curves of the lower series are the curves of atomic volume, and the curves of the upper series show the melting points of the elements.

NOTE ADDED IN PRESS.—This rule is only an approximation. Strictly speaking, the increments of atomic weight which give the positions of lowest atomic volume are alternately equal to the lateral dimensions of a pair of equal cycles and to the mean lateral dimensions of a pair of adjacent unequal cycles.

INDEX

TO

VOLUME III. OF THE PROCEEDINGS.

(SECOND SERIES.)

SCIENCE.

"The accompanying book, from pages 1 to 9 inclusive, consists of sketches of rock-structure more or less developed, in the sand-hills of Doolin and Liscanor Bays, in the County Clare. These sketches were made in 1868, but I had several years previously noticed the same appearances at Ballybunion, in Limerick, and I had observed a general agreement between these crude formations and the rock-structure of the adjoining districts.

"No. 10 is the only sketch I have preserved of like appearances in transported clay. It is a highly laminated mass, taken from an artificial embankment near Ragatz. But all the adjoining alluvium is of similar structure, due to its deposit by the Rhine, and this lump may have been taken from a mass thrown up from the flat, which would neutralize its evidence. Its structure is horizontal. I regret that I have lost my drawing of a vertically divided face of clay exposed in the mound of an ancient earthen fort at Bull Head, Dingle. I made many other observations of like structural tendencies in hand-transported masses of mud, clay, and quarry *débris* at Vichy, Gastein, and at Buxton; but I lost my notes of these at Truro, two years ago. One of the most striking examples I had noted was a mass of road-stuff on the highway, south of Werfan, on the way to Gastein, which appeared to me to show a remarkable likeness in structure to the highly laminated gneiss rock of the district.

"It is with great diffidence I say anything of glaciers; but noticing no agency of pressure to account for the blown sand or adventitious clay cleavages, I was early led to question the theory which assigns to pressure the rock-like structure noticeable in some ice formations. The sketches from Nos. 11 to 21 inclusive were made with the analogies which those cleavages suggest before my mind, and they may have unconsciously influenced my pencil. But I fancy Professor Forbes, in his 'Alps of Savoy,' had not these considerations to mislead him, when he made his drawings of the very distinct rock structure displayed in the glaciers of the Brenva (p. 203) and Macugnaga (p. 347).

"If my impressions of the existence of a real analogy between the effective causes of those appearances be, to any extent, probable, it may appear desirable to the Academy to possess the original sketches made with a view to investigations which the publication in 'Nature' will soon cause to be taken up by more competent inquirers. I would, therefore,

ask, through you, to solicit the permission of the President for you to read this letter, and present the drawings which accompany it to the Royal Irish Academy, at its next meeting.

"I remain,

"Dear Dr. Wright,

"Very faithfully yours,

"SAMUEL FERGUSON.

"ED. PERCEVAL WRIGHT, M.D.,

"*Secretary, Royal Irish Academy.*"

A special vote of thanks was given to Dr. Ferguson for his presentation.

The Secretary laid on the table Part 6 of Vol. XXVI. of the "Transactions," being a Report on the Allotropism of Selenium, and on the Influence of Light on the Electrical Conductivity of this Element, by Harry N. Draper, and Richard J. Moss.

Donations to the Library were announced, and thanks voted to the Donors.

THURSDAY EVENING, NOVEMBER 30, 1876.

(St. Andrew's Day.—Stated Meeting.)

VERY REV. WM. REEVES, D.D., Dean of Armagh, Vice-President, in the Chair.

The Rev. Canon Burke signed the Roll, and was admitted a Member.

The Right Hon. Lord Talbot de Malahide, F.R.S., was elected a Member of Council in the Department of Polite Literature and Antiquities, to supply the place of the Rev. M. H. Close, M.A., resigned.

A Paper, by the Rev. D. H. Haigh, "On Early British and Irish Inscriptions," Part 2, was read.

By permission of the Academy, Mr. F. Ogilby Ross read a Paper, "On the Myology of the Cheetah (*Felis jubata*)."

[This Paper will appear in the "Proceedings," Second Series, Vol. III., Science, Part 1.]

MONDAY EVENING, DECEMBER 11, 1876.

SAMUEL FERGUSON, LL.D., Vice-President, in the Chair.

The Secretary of Council read a description, by Miss M. Stokes, Honorary Member of the Academy, of a Series of Photographs of Early Irish Architecture.

It was resolved—"That the thanks of the Academy be given to Miss Stokes for the opportunity she has afforded it of examining the splendid series of Photographs of Early Irish Architecture now exhibited; and for her kindness in accompanying this exhibition with so valuable a description."

Donations to the Library and Museum were announced, and thanks voted to the Donors.

MONDAY EVENING, JANUARY 22, 1877.

VERY REV. WM. REEVES, D.D., Dean of Armagh, Vice-President, in the Chair.

It was resolved—"That a congratulatory address be presented to his Grace the Duke of Marlborough, Lord Lieutenant of Ireland, and that the Officers of the Academy be and are requested to prepare the same."

The Officers, having retired, returned with the following draft of an address, which was adopted:—

"MAY IT PLEASE YOUR GRACE—

"We, the President and Members of the Royal Irish Academy, beg leave to approach your Grace with our respectful congratulations on your arrival amongst us as the Representative of our Most Gracious Sovereign.

"The learned body to which we have the honour to belong was constituted by Charter in the year 1785, for the purpose of promoting the study of Science, Polite Literature, and Antiquities. Since that time it has laboured, not without success, in this high vocation, and has won an honourable place amongst kindred Societies at home and abroad.

"It has provided a field and supplied a stimulus for the development and exercise of Irish genius. It has made important contributions to knowledge in various branches of scientific inquiry; it has brought together in its Museum and Manuscript Collection abundant and trustworthy materials for the illustration of our National Antiquities, and of the language, literature, and social life of the Hiberno-Celtic race.

"Your Grace is, by virtue of your exalted office, Visitor of the Academy. We trust you will find reason to look on its labours with the same favour with which they were regarded by your distinguished predecessors in the government of Ireland; and we are sure we may rely on your Grace's countenance and support in our endeavours to guard its interests, maintain its character, and extend its usefulness."

It was Resolved—"That the Officers of the Academy take the proper steps to have the same presented to his Grace."

Samuel Ferguson, LL.D., V.P., read a Paper "On some Sculptures on the Great Cross at Clonmacnoise."

By permission of the Academy, Chichester Bell, M.D., read a Paper "On a Series of Bases derived from Pyrrol, and some Compounds allied to them and to Mussic Acid."

[This Paper will appear in the "Proceedings," Second Series, Vol. III., Part 1.]

By permission of the Academy, Dr. E. L. Moss, R.N., read a Paper "On the Glaciation by Sea Ice."

[This Paper will appear in the "Proceedings," Second Series, Vol. III., Science, Part 1.]

Professor J. E. Reynolds read the second of a series of Reports from the Chemical Laboratory of Trinity College, Dublin. No. 2. "On Mr. Early's Method of Analysing Ferroso-ferric Silicate."

[This Report will appear in the "Proceedings," Second Series, Vol. III., Science, Part 1. For No. 1, *vide* "Proceedings," Second Series, Vol. II., p. 731.]

MONDAY EVENING, MARCH 5, 1877.

(Special Meeting.)

SAMUEL FERGUSON, LL.D., Vice-President, in the Chair.

The Secretary of Council announced that the President of the Academy had intimated that he would not present himself for re-election at the approaching Stated Meeting.

The Secretary of Council read the following Report of the Council as to negotiations with the Government, and the letters from the Government communicating the conditions proposed as to the transfer of the Museum of the Academy to the new "Science and Art Museum," and as regards the re-transfer of the Vote for the Academy to the charge of the Irish Government, as well as to the future provision for the maintenance and augmentation of the collection of Antiquities.

REPORT OF THE COUNCIL.

ON the last occasion (26th of June, 1876), when the Academy had under its consideration a Report from the Council in relation to the question pending with the Government as to the transfer of the charge of its Vote from the Chief Secretary for Ireland to the Science and Art Department, a Petition to the House of Commons on the subject was adopted, and the Council were authorized to take the requisite steps for its presentation, if they should find it advisable. Further time having elapsed without any communication having been received from the Government, and the close of the Session being at hand, your Petition was entrusted for presentation to the Members for the City of Dublin, and just before the rising of Parliament was presented by Mr. Maurice Brooks, and was one of those selected by the Committee on Public Petitions to be printed in their last Report for the Sessions (31st Report, Appendix, p. 228).

The Council were gratified to observe that the attention of the House of Lords was called to the subject by Lord O'Hagan, who moved for a Return of "copies of all public official correspondence (commencing 8th of February, 1876) between the Irish Government, the Treasury, the Science and Art Department, the Royal Dublin Society, and the Royal Irish Academy, on the subject of the proposed Establishment of a Science and Art Department in Dublin."

This motion was acceded to on the part of the Government by the ke of Richmond and Gordon, Lord President of the Privy Council. About the same time your Council received from their Excellencies Lords Justices of Ireland (in the absence of His Grace the Duke of rcorn) an intimation of their willingness to receive a Deputa- on the subject of the transfer of the Academy's Vote. They ordingly waited on their Excellencies (the Lord Chancellor and Vice-Chancellor) at Dublin Castle, on the 27th June, 1876, and sented the following Memorial, the importance of which seems to Council to justify their now placing it before the Academy:—

"May it please your Excellencies,

"We, the Council of the Royal Irish Academy, beg to approach your Excellencies in the hope of inducing you to exercise the influence of your high office to obtain a reversal of the action of certain Departments of the Government, by which the charge of the Parliamentary Vote for the Academy has been transferred from the Irish Government to the Science and Art Department, South Kensington.

"It is probably within the knowledge of your Excellencies that a communication was, in February last, addressed to the Academy by the Right Hon. Viscount Sandon, Vice-President of the Committee on Education of Her Majesty's Privy Council, propounding a scheme which involved a proposal for the transfer of the Academy's Collection of Antiquities to a Science and Art Museum in Dublin, to be provided by the State, under an officer of the Establishment known as the Science and Art Department, who would be the medium of communication with that Department.

"The Academy, whilst consenting to the proposed transfer, attached thereto certain conditions, and, amongst others, the following:—That the Academy should not be subject, in the conduct of its affairs, or the expenditure of its grants, to any control on the part of the Science and Art Department, or any of its officers; and should continue to be accountable, as at present, through Her Majesty's Irish Government, for all sums voted by Parliament.

"To the letter embodying these conditions we have never received any reply, further than a formal acknow-

opposition to the establishment of a Science ar
in Dublin, and is thus impeding the bestowal of
on the people of Ireland. No representation
unfounded. What was sought from us in
letter was the union of our Antiquarian Collect
posed new Museum. To this we distinctly asse
tions such as we thought were required in the
country, involving arrangements similar to th
accorded in a like case to the Scottish Society
and under which the National Collection of
England is managed by the Trustees of the B
without interference from the Science and A
which has no concern with Archæology.

"The only reasons given for the transfer of
our Vote are founded in misapprehension. I
such a change was recommended by the Co
1868. But this is an erroneous statement, no
the Report of the Commissioners, and contradic
them, who have come forward to repel the asse

"The other reason alleged is, that the chan
troduced to further a proposed amalgamation
Institutions in Dublin.' But the Governmen
its sanction to any such amalgamation, and it w
in Lord Sandon's letter. The project of such a
has been rejected by the Academy, and the i
on a reluctant body may be treated as qu

pying in this country a position analogous to that of the Royal Society in England, and, in Scotland, of the Royal Society of Edinburgh. We feel bound to maintain it on the same level of dignity with those bodies, and not to accept for it a subordination which, we doubt not, they would repudiate as unbecoming their position. Those distinguished Societies have not been placed under the financial or other control of the Science and Art Department; and when the step has been taken in relation to them, it will be time enough, we submit, to propose it to us.

"That a control exercised by the Department over the Academy in monetary matters would extend to the scientific and literary sphere, we have no doubt; and we believe the Department to be entirely unfitted to exercise any such authority over the proceedings of a body like the Academy.

"The Irish Government is the natural guardian of the rights of the body which is the chief representative of Science and learned research in Ireland. It is likely to be better informed than any other on our position, our deserts, and our requirements. Our connexion with it has worked in a perfectly satisfactory manner. That this connexion should be terminated, and the charge of our grant transferred to a Body in London, appears to us an unnecessary disturbance of relations which were not complained of. To quote words used by the Academy in 1862, when deprecating a similar attempt, such an innovation would 'compromise the honour and interests of an important National Institution, for an alleged official convenience of the most inconsiderable kind.'

"We find it difficult to believe that the distinguished nobleman who now presides over the Irish Government could have consented to the transfer of the charge of the Academy's vote,' if His Grace had been aware of the unreality of the reasons assigned for the change. And we are confirmed in this opinion by the fact that His Grace has lately marked his confidence in the Academy by requesting, without any application from us to that effect, that we would undertake the editing of certain Irish Annals, the publication of which was considered by His Grace important, but has been suspended by the untoward action now complained of.

Science and Art for Ireland,' which, as state
Hunt, then Chancellor of the Exchequer, shoul
to, and not subordinate to, the English establish

"It is not alleged that there is anything
state or recent proceedings to supply a motive f
with us. Never has the work of the Academy l
with greater energy or industry than at pr
Departments are in a state of healthy activity.
its former operations, by the aid of the increase
it has of late enjoyed, it has stimulated and
scientific research, and is multiplying, for
scholars at home and abroad, copies of the most
Manuscripts. It cannot be alleged that there is
want of circumspection in applying the funds pl
posal by the bounty of Parliament. Why, then, s
be made in its position, offensive to its Member
ous to its public usefulness?

"The Academy depends, for its reputati
learned Societies of the world, and for its bene
at home, without which it had better cease t
voluntary researches and unpaid personal servic
bers. Such helps to learning do not flourish ex
conditions of conscious independence, and a cont
security; and we are convinced that the change
we protest would, if carried out, be, in a great d
tive of the higher motives to scientific and liter

Their Excellencies received the Deputation very graciously, and veyed to those present the impression that the views submitted e looked upon favourably by their Excellencies.

About this stage of the negotiations a sum of £500, portion of £2000 voted to the Academy by Parliament (in addition to £500 ady received through the usual channel) was placed, unasked for, the credit of the Academy by the Paymaster-General, and subuently we received an intimation that it had been issued by the ence and Art Department.

No reply to our communications, however, was received for some nths, and the Council became apprehensive that it would be necesy for them, in order to meet the urgent requirements of the demy, to have recourse to its funded capital, under the authority eived from the Academy, authorizing them, if necessary, to sell a porn of its invested property. Before, however, taking so serious a step, was thought advisable to apply to the Bank of Ireland for permission overdraw to the extent of £500. The Council think it right to knowledge the prompt and liberal manner in which this request s granted by the Governor of the Bank.

An intimation having been received from the Chief Secretary, that desired a conference on the subject at issue between the Government and the Academy, the Secretary of Council had interviews h him, which resulted in the adoption by the Council, on the 4th December, 1876, of the following Resolution:—

"That the Council is prepared to re-open negotiations for the nsfer of its Museum to the new establishment in Dublin, contemted by the Government, on the following basis, viz.:—That after h transfer, if it should be agreed upon, the part of the Academy's nt given for the care and maintenance of the Museum shall be acnted for by the Department of Science and Art, the Academy aining the same amount of control over the management of its lection as is enjoyed in a similar case by the Scottish Society Antiquaries, and due provision being made for its preservation its integrity as a National collection in Dublin, whilst the rest of Academy's grant shall remain on its present footing, and shall tinue to be accounted for as heretofore by the Chief Secretary for land."

On the appearance of the Civil Service Estimates for 1877-8, early

last month, it was found that the Academy's Parliamentary Gr longer appeared amongst the Irish votes, but under those accounted for by the Science and Art Department.

It was, therefore, all the more gratifying to the Council to r immediately afterwards the Letters which it now hastens to municate to the Academy. They are, for convenience, arrang chronological order.

[1.]

"Science and Art Department,
"South Kensington, S.W.,
"8th February, 18

"Sir,

"The Lords of the Committee of Council on Education have their careful consideration to Sir Michael Hicks Beach's letter, 7th November, 1876, to the Secretary of the Treasury, on the su of the re-transfer of the vote for the Royal Irish Academy to the Government, which was forwarded by Mr. Law to this Depart on the 16th November.

"I am to request that you will inform the Lords Commissi of Her Majesty's Treasury, that the Lords of the Committee of Co on Education are glad to find that the general scope of the prop of the Royal Irish Academy, as they anticipated would be the ca not inconsistent with their views as expressed in my letter of th February, 1876.

"It is hardly necessary to remind their Lordships that the sc proposed in that letter was always considered to be open to such m fications in details as might appear to be desirable, after the Gov ment had had the advantage of hearing the criticisms upon it of gentlemen in Ireland who, from their knowledge and experi have a just influence in such matters, provided always that the m fications did not interfere with the ultimate success of the great o which Her Majesty's Government had in view, namely, the estab ment in Dublin of a comprehensive National Museum of Science Art, which has been generally desired for many years.

"My Lords are, therefore, prepared to accede to the suggestion of the Royal Irish Academy, that the same course should be taken respecting the collection of the Academy as that which was adopted by the Treasury with regard to that of the Society of Antiquaries of Scotland. Their Lordships might not unreasonably have demurred to placing the Royal Irish Academy in a similar position to the Society of Antiquaries of Scotland, inasmuch as the collections of the latter were all acquired by private funds, whereas a large proportion of those of the Royal Irish Academy have been purchased out of funds provided by Parliament; but My Lords are willing to waive these considerations, so as to consult, as far as possible, the wishes of the Royal Irish Academy, and they propose to follow closely the precedent of the Treasury minute of 1851, respecting the Scotch Society, only introducing such modifications as are absolutely required by the different circumstances of the two cases.

"My Lords, therefore, desire to call the attention of the Lords Commissioners of the Treasury to the appended copy of a minute (in which the necessary alterations are shown in red ink) as embodying the conditions under which the Lords of the Committee of Council on Education are of opinion that the proposals of the Royal Irish Academy should be accepted.

"On receipt of a resolution of the Academy accepting the conditions appended, and undertaking to transfer their collections to the new Science and Art Museum, as soon as the building is ready to receive them, My Lords will be prepared to recommend to the Lords Commissioners of Her Majesty's Treasury that the votes now taken for the Royal Irish Academy shall be re-transferred to the Irish Government, it being understood that the votes now taken for Museum purposes by the Royal Irish Academy shall cease as soon as the Science and Art Museum is ready to receive their collections.

"I have, &c.,

"(Signed), SANDON.

"THE SECRETARY

"TO THE TREASURY."

"CONDITIONS.

"1. The entire collection of antiquities, coins, and medals, be-

longing to the Royal Irish Academy, with such additions as may be hereafter made to them, and the cabinets, glass cases, &c., in which they are contained, to be conveyed to the Lords of the Committee of Council on Education, to be retained in Ireland on behalf of the public.

"2. Fit and proper accommodation to be at all times provided in a public building for the preservation and exhibition to the public of the collection of antiquities, and for the meetings of the Royal Irish Academy; but no stipulation can be entered into permanently to appropriate particular apartments in the new Museum building to these objects.

"3. The charge and custody of the collection of antiquities to be entrusted to the Royal Irish Academy, subject to such regulations and special directions as may from time to time be prescribed by the Lords of the Committee of Council on Education.

"4. The funds required to alter and adapt the apartments in the Science and Art Museum for the reception of the collection, to furnish the requisite means for the preservation and exhibition of the Museum, and to pay the salaries of additional servants, to be provided by the Lords of the Committee of Council on Education, by an estimate to be submitted to Parliament.

"My Lords are of opinion that it would not be conducive to the object which all parties have in view, in making this arrangement, that express stipulations should be entered into with the Royal Irish Academy on detailed points of management; but the Members of that Society may rest assured that it will be the desire of the Lords of the Committee of Council on Education so to exercise the general control which they must retain over all collections exhibited at the public expense as to leave the Royal Irish Academy as unfettered in the charge and management of the Museum as circumstances will allow."

[The alterations shown in red ink in the original are underlined above.]

[2.]

"TREASURY CHAMBERS,
"17th February, 1877.

"SIR,

"I am directed by the Lords Commissioners of Her Majesty's Treasury to transmit to you herewith copy of a letter of the 8th inst. from the Science and Art Department, and of the enclosure therein, on the subject of the re-transfer to your Department of the vote for the Royal Irish Academy; and I am to state, that if the proposal now made meets with the approval of His Grace the Lord Lieutenant, My Lords should not feel called upon to make any objection to it.

"I am, Sir,
"Your obedient Servant,
"W. H. SMITH.

"THE RIGHT HON.
"SIR M. HICKS BEACH, Bart., M. P."

[3.]

"DUBLIN CASTLE,
"26th February, 1877.

"SIR,

"Adverting to former correspondence relative to the transfer of the antiquarian collections commonly known as the Museum of the Royal Irish Academy, to the National Science and Art Museum, which it is proposed to establish in Dublin; and also to the transfer of the charge of the vote for the Royal Irish Academy to the Science and Art Department, I am directed by the Lord Lieutenant to acquaint you, for the information of the Royal Irish Academy, that His Grace has been in communication with the Lords Commissioners of Her Majesty's Treasury and the Science and Art Department on the subject, with the view of devising such modifications in detail of the original scheme proposed in Lord Sandon's communication of the 9th February, 1876, directed to the President of the Academy, as, while not interfering with the establishment in Dublin of a comprehensive National Museum of Science and Art, would at the same time meet the objections entertained by the Members of the Royal Irish Academy to the original scheme, and also to the transfer of the

charge of their vote from the Lord Lieutenant to the Science and Art Department.

"His Grace desires me to transmit herewith a copy of a letter dated 17th instant, received from the Treasury, together with a copy of a letter enclosed therein from the Science and Art Department, and in which a modified scheme is proposed.

"His Grace feels assured that the Academy will receive this proposal in the same friendly spirit in which it is made, and he confidently trusts that it will meet with their approval.

"I am, Sir,

"Your obedient Servant,

"T. H. Burke.

"The Secretary,

"Royal Irish Academy."

It is to be observed that whilst the Government has, on the one hand, stipulated for certain conditions, which, *mutatis mutandis*, are identical with those to which the Society of Antiquaries of Scotland readily assented, on the other hand, in deciding "that the proposals of the Academy should be accepted," Government has conceded the conditions sought by the Academy, not only as regards the re-transfer of its vote to the charge of the Irish Government, but also as to the future provision for the maintenance and augmentation of the Museum, and its preservation in Dublin as a Museum of our National Antiquities, distinct from other collections, and under the care and management of the Academy.

The Council, being of opinion that the Government has virtually agreed to all that was sought for by the Academy, either in its own interest or for the benefit of the Irish public, have no hesitation in advising the Academy cordially to accept the terms proposed by the Government, and they recommend the Academy to authorize the Council to take all steps necessary to bring the negotiations to a close.

The Secretary of the Council moved the adoption of the Report.

It was moved, as an amendment, by George Sigerson, M.D., and seconded by James John Kelly, Esq.:—

"That it be referred back to Council to report that, as to paragraph 3, they do not recommend the Academy to accept that condition, unless the words, 'unless the Academy object to any particular rule or regulation,' be added thereto."

The proposer and seconder of the foregoing amendment, by permission of the Academy, having withdrawn it, the Report was adopted.

It was moved by J. Kells Ingram, LL.D., seconded by Sir Robert Kane, F.R.S., and Resolved unanimously—

"That the Academy, accepting the conditions set forth in the letter of Lord Sandon (of February 8, 1876), recently transmitted by the Irish Government, undertakes to transfer its Museum to the proposed National Museum of Science and Art in Dublin, as soon as the building may be ready to receive it; and desires at the same time to express its sense of the considerate manner in which Her Majesty's Government have met the views of the Academy."

The Academy then adjourned.

FRIDAY EVENING, MARCH 16, 1877.

(Stated Meeting.)

SAMUEL FERGUSON, LL.D., Vice-President, in the Chair.

On the proposition of the Chairman,

It was Resolved—

"That Bye-law 4 of Chapter IX. be for the present suspended."—

Visitors were then admitted.

The Secretary of the Council read the following letter from the President:—

"5, MERRION-SQUARE, NORTH, DUBLIN,
"*March*, 14*th* 1877.

"MY DEAR DR. INGRAM,

"I am compelled by the state of my health to ask you to announce at the Stated Meeting that it is my desire to retire from the office of President of the Academy, which I have always held to have been the greatest honour of my public life.

"I beg you will convey to all the Members of the Academy my feelings of gratitude, and my earnest thanks for the distinction they have conferred upon me, and the kindness they have invariably shown me while I filled the office.

"Faithfully and gratefully yours,

(Signed) "WILLIAM STOKES."

It was moved by Lord Talbot de Malahide, and seconded by Dr. Lyons, and

Resolved unanimously :—

"That the Academy receives with much regret the announcement of the retirement of Dr. Stokes from the office of President; and that the Secretary be requested to convey to him the grateful thanks of the Academy for the eminent services rendered by him in its behalf, and for his dignified and zealous discharge of his functions as President of the Academy."

It was proposed by James Apjohn, M. D., F. R. S., and seconded by Alexander G. Richey, LL.D :—

"That Sir Robert Kane, F. R. S., &c., be elected President of the Academy."

It was proposed by Rev. J. H. Jellett, B. D., and seconded by Lord Talbot de Malahide, F. R. S. :—

"That the Rev. Samuel Haughton, F. R. S., &c., be elected President of the Academy."

The Ballots for President and Members of Council, and Officers, and for an Honorary Member, being opened, the Chairman appointed Rev. Dr. Carson and Dr. M'Sweeny Scrutineers for the election of President, Council, and Officers; and Mr. Porte and Mr. G. C. Garnett Scrutineers for the election of Honorary Member.

The Secretary of Council brought up the following Report of the Council for the year 1876–77 :—

Report of the Council for the Year 1876–7.

Since the date of the last Report of the Council, the following Parts of the Transactions have been published:—

In the department of Science:—

Vol. XXVI.—Part 4. On ω Leonis, considered as a Revolving Double Star; by W. Doberck, Ph. D.

Vol. XXVI.—Part 5. Report on the Exploration of Shandon Cave; by Professor A. Leith Adams, F. R. S.

Vol. XXVI.—Part 6. Report on the Allotropism of Selenium, and on the Influence of Light on the Electrical Conductivity of this Element; by Harry N. Draper, F. C. S., and R. J. Moss, F. C. S.

And the following is in the press:—

Vol. XXVI.—Part 7. Catalogue of, and Observations on, the Red Stars; by John Birmingham.

In the department of Polite Literature and Antiquities:—

Vol. XXVII.—Part 1. On the Bell of St. Patrick; by the Very Rev. William Reeves, D. D., is in type and will be laid on the table at this Meeting.

Dr. Whitley Stokes' Edition of the Felire of Oengus is still in progress. The entire triple text and translation have been printed, and the Glossary is now being proceeded with. To accelerate the completion of the work, the Council have authorized the Editor, at his request, to have the Glossary printed at Calcutta, care being taken to make it harmonize in style with the rest of the volume.

Dr. William K. Sullivan's Edition of the Tain-bo-Cuailnge is also still in the printer's hands.

Of the Science portion of the New Series of our Proceedings, there have been published within the year, Part 6 of Vol. II., in July, 1876, and Part 7, in January of the present year (1877.) These Parts contained all the Science Papers (with three exceptions) laid before the Academy in the Session of 1875–6. Part 12 of Vol. I. (Second Series), containing papers on Polite Literature and Antiquities, will very soon be ready for issue.

Within the past year, papers by the following authors were read before the Academy:—

In the department of Science:—by Professor R. S. Ball; Mr.

G. H. Kinahan; Dr. Doberck; Professor J. Emerson Reynolds; Dr. David Moore; Mr. E. T. Hardman; Professor E. Perceval Wright; Mr. A. G. More; Professor Edmund Davy; Rev. J. H. Jellett; Mr. Harry N. Draper and Mr. Moss; Mr. George Porte; Professor J. R. Young; Dr. Moss; Mr. John Birmingham; Dr. Samuel Ferguson; Mr. A. M'Alpine; Professor M'Nab; Mr. J. Blackwall and Rev. O. P. Cambridge; Mr. F. Ogilby Ross; Dr. Chichester Bell; Mr. H. B. Brady; Mr. C. E. Burton; Professor Henry Hennessy; Mr. J. E. L. Dreyer, and Dr. Angus Smith.

In the department of Polite Literature and Antiquities:—by Mr. W. F. Wakeman; Dr. Samuel Ferguson; and Rev. D. H. Haigh.

Miss Stokes, Honorary Member of the Academy, exhibited at one of our Meetings a splendid series of photographs, illustrative of Early Irish Architecture, and accompanied the exhibition with a communication containing a description of the structures thus represented, and also a general view of the History of our Architecture down to the Anglo-Norman invasion.

The Librarian has found it necessary to undertake an entire re-arrangement of the Library. All books relating to Ireland have been brought together into the recesses of the gallery facing the entrance. Books on archæological matters (in the widest sense) are being gradually transferred to the Reading-room, in which, when all are collected, it is intended to arrange them on a system of classification which will enable readers to discover at once the literature of each subject and of its particular branches, so far as it is contained in the Library. The foreign reviews and other periodicals have been collected from all parts of the Library, and placed in the recesses on the north side of the room, where they are arranged according to the countries in which they are published.

In the department of manuscripts, we have to report, with respect to the Edition of the Book of Leinster, which we have undertaken with the assistance of the Board of Trinity College, that the transcription has been continued as far as page 300, and that 280 pages have been already printed off. It is expected that the whole of the work will be completed in the summer of 1879.

Dr. Atkinson, by appointment of the Academy, appeared as its Delegate at the International Congress of Orientalists, which met at St. Petersburg in September, 1876.

Since the date of our last Report, various objects of interest have been added to the Academy's Museum. Amongst these may be specially mentioned portions of a beautifully carved Harp, bearing inscriptions in Irish, and the date, 1621, known as the "Dalway Harp;" a set of silver-mounted ivory Bag-pipes of the middle of the last century; and an ancient Boat, recently found in the County of Galway—the last being a donation from the Rev. Sir William Ross Mahon, Bart.

The valuable collection of Irish antiquities belonging to the late Mr. Walsh of Dromore has also been purchased, comprising objects in gold, silver, and amber; weapons and other articles of bronze, flint, and stone; wooden utensils, earthen cinerary urns, &c. All these have been temporarily deposited in wall-cases, on the south side of the Reading-room gallery. The arrangement of the Museum in the first floor and basement continues to advance with systematic regularity. Its condition is now eminently satisfactory.

The decorative painting of the walls and ceilings of the Long Room has just been completed by the Board of Works, and a considerable improvement thus effected in the general appearance of this part of the Museum.

The Hand-book for Visitors to the Museum, intended for popular use, which was announced in our last Report as in preparation, has since been published, and will, we trust, contribute to a more general understanding and appreciation of our antiquarian collections—especially by such of the working classes as may avail themselves of the evening opening.

It will be remembered that in April, 1875, the Council offered Two Premiums of Fifty Pounds each for the best Reports or Essays on the present state of the Irish Language and Literature in the Provinces of Ulster and Leinster. Three Essays were sent in to compete for these Premiums. The Council were not of opinion that any of these Essays was of a nature to deserve the full award of a Premium. But the knowledge and industry displayed by one of the writers, Mr. Francis Keane, seemed to entitle him to a substantial mark of consideration, and they accordingly presented to him a sum of Twenty Pounds as an honorary donation.

The most important part of the work of the Council during the past year consisted of the negotiations and other proceedings ren-

dered necessary by the unsettled state of the relations between the Government and the Academy. A detailed account of these has already been laid before the Members, and they are therefore not dealt with in the present Report. From the resolution of the Academy not to acquiesce in the transfer of the charge of its vote from the Irish Government to the Science and Art Department, it resulted that a large portion of the Parliamentary Vote did not reach us in time to be applied to the objects to which it would, in the ordinary course, have been devoted. We were thus obliged to defer proceeding with the printing of the "Annals of Ulster," though the publication of that work had been undertaken by us at the instance of the late Lord Lieutenant of Ireland. To the same cause it is due that we were not able until near the end of the past year to distribute the fund annually placed at our disposal by Parliament for aiding Scientific Research by providing suitable instruments and materials. While constrained to exercise a cautious reserve with respect to these items of our expenditure, we endeavoured, as far as possible, to prevent what we regard as the most important part of the Academy's work—namely, the printing of Papers read before us—from being seriously obstructed by the temporary failure of our supplies. Now that a satisfactory solution has been arrived at of the questions so long at issue between the Academy and the Government, the Papers read since November last will speedily be published, and it may be confidently expected that every branch of our operations will proceed with renewed energy and efficiency.

The grants in aid of the preparation of Scientific Reports, recommended by the Committee of Science, approved by the Council, and now submitted for the sanction of the Academy, are as follows:—

£50 to Rev. Professor Haughton, M. D., for Reports on the Tidal Constants of the Irish Coast; being the second instalment of the sum of £100 required for the expenses of calculations.

£10 to Dr. C. Bell for further Experiments on Pyrrol.

£50 to Dr. R. S. Ball towards the expenses to be incurred in the reduction of the recorded Observations of Jupiter's Satellites, preparatory to a re-discussion of their Theory.

£25 to Dr. Reynolds and Rev. Professor Haughton, M. D., for Experiments on the Dynamical Coefficients of Friction, at low velocities, between fluids and solids.

£25 to Rev. J. H. Jellett, B. D., for Experiments on the action of Galvanic current on a beam of polarized light.

£40 to Dr. E. P. Wright, towards defraying the expenses of obtaing a series of drawings of some of the lower Algæ—the drawings to the property of the Academy.

The Council have addressed to the Commissioners of Church Temralities a request that they will, so far as they are empowered by e Irish Church Act of 1869, cause all the Ecclesiastical Round owers to be treated as National Monuments; and, further, that they ill take steps to have the buildings at Clonmacnoise, including the ower, placed in charge of the Board of Works, and revested, so as come within the operation of the Act. We have reason to believe at this representation will be attended with satisfactory results.

Fourteen Ordinary Members have been elected since the 16th of arch, 1876, viz.:—

1. Michael F. Coxe, M. D.
2. Francis E. Clarke, M. D.
3. Rev. John Grainger, D. D.
4. Rev. William McIlwaine, D. D.
5. Walter Meyers.
6. G. Gerald Tyrrell.
7. William H. Byrne.
8. William Gillespie.
9. James Edward Kelly, M. D.
10. Rev. Richard Travers Smith, B. D.
11. Harry N. Draper.
12. The Earl of Leitrim.
13. Marriott R. Dalway, M. P.
14. Rev. Hill Wilson White.

We have lost by death within the year one Honorary Member—

The Abbé Jean Benoit Désiré Cochet, elected in 1863;

d nine Ordinary Members, viz.:—

1. Rev. J. Bewglas, elected January 8, 1849.
2. Edward Bewley, elected December 11, 1843.
3. Adolphus Cooke, elected June 9, 1845.
4. Sir John Esmonde, Bart., elected January 10, 1870.

and a few words must here be said of the great s
dered to Irish Archæology, and the labours which
an eminent degree to our grateful remembrance.
years a devoted student of the history and ant
country, he became in after-life an earnest c
school which, discarding the fanciful doctrines and
of inquiry which had so long disfigured and d
archæological study, proposed to itself to subject re
kind to the rigorous discipline of scientific method.
himself the idea that in our Museum were to be fo
most precious materials for the social palæontology of
for the study of its primitive races, their ideas, mann
life—he applied himself to the classification and ca
contents, with the double view of assisting the system
enlightening the general mind of our people on these
only did he prepare himself for this task by a lengthe
study of the collection itself, but, while the work was
visited the principal Museums of Northern Europe
quaint himself by personal inspection with the analog
which connect Irish pre-historic remains with those
This indicates an important feature in the spirit whic
his researches, namely, the habitual application, i
inquiry, of the comparative method which is now univ
ledged to be one of the most effective instruments
archæology and the early history of mankind. He
Catalogue of the gold, copper and bronze articles in o
of the objects composed of stone, earthen vessels,

rendered necessary by the growing requirements of the Museum, the order of his arrangements has been scrupulously preserved; and, by a system of key-reference adopted in the re-deposit, the connexion of each article with its description in the Catalogue has been maintained unbroken.

The labours of Sir William Wilde were not restricted to the field of antiquarian study. His "Narrative of a Voyage to Madeira," his work on Austria, his "Popular Superstitions of Ireland," his "Closing Years of Dean Swift's Life," and his works on Irish Topography—so abounding in local and traditional knowledge, and so marked by genial appreciation both of the national character and of the beauties of the scenes described—all these are literary works of distinguished merit; whilst his professional writings, of which his Treatises on Aural Surgery may be specially mentioned, and his Reports contributed to the volumes of the Irish Census, give him an honourable place in the domain of Science.

Of his practical exertions for the benefit of his profession, or the good of his fellow-countrymen generally, this is not the fitting occasion to speak; nor of the kindly spirit and attractive social qualities which won for him a large circle of admiring friends.

Various honorary titles and decorations were conferred upon him in recognition of his public services. He received a Diploma from the University of Upsala, and was elected an Honorary Member of the Society of Antiquaries of Berlin. He was also presented with a decoration of the Order of the Polar Star, thus becoming a Chevalier of the Kingdom of Sweden. He received the honour of Knighthood in acknowledgment of his services to Statistical Science in connexion with the Irish Census. The Board of Trinity College conferred on him the Degree of M. D., *honoris causâ*. And this Academy, by presenting to him the Cunningham Medal, the highest special mark of distinction in its power to bestow, expressed its grateful sense of the service rendered to Scientific Archæology in general, and to our body in particular, by his Catalogue of the Museum.

A brief tribute should also here be paid to the memory of Colonel Meadows Taylor. Endowed with talents of a high order, and gifted with indefatigable industry, he some fifty years since left Ireland for Bombay, as a clerk in a mercantile house. On his arrival

geological features and literature of the country.
appointed to administer, during a long minority, t
of the young Rajah of Shorapore, and during the mu
was able to hold his ground without requiring any mi
merits were highly appreciated by the British Governi
retirement from service he received from Her Majest
being made a Companion of the Star of India. His t
ledge and sympathetic appreciation of the ideas and
native races of India were exhibited in several able
works of fiction, the scene of which was laid in that c

Our Transactions and Proceedings contain several va
tions from his pen, amongst which may be named
of Indian Musical Instruments," "Description of th
Cairn at Hyat Nuggur in the Dekhan;" and "a
Cairns, Cromlechs, Kistvaens, and other Monuments i
In the numerous illustrations, from his original s
accompany the last-mentioned memoir, there is evide
known artistic powers. Those who had the pleasu
Colonel Taylor will long retain the impression made c
combined earnestness and gentleness of his character, a
charm of his conversation and manners. He was for
Member of the Council of the Academy.

The Report was adopted.

The following Grants, recommended by the Cou
Parliamentary Grant for the preparation of Scientific
adopted:—

£50 to Dr. R. S. Ball towards the expenses to be incurred in the reduction of the recorded Observations of Jupiter's Satellites, preparatory to a re-discussion of their Theory.

£25 to Dr. Reynolds and Rev. Professor Haughton, M. D., for Experiments on the Dynamical Coefficients of Friction, at low velocities, between fluids and solids.

£25 to Rev. J. H. Jellett, B. D., for the Experiments on the Action of a Galvanic Current on a Beam of Polarized Light.

£40 to Dr. E. P. Wright, towards defraying the expenses of obtaining a series of drawings of some of the lower Algæ—the drawings to be the property of the Academy.

The Scrutineers having duly reported, the Vice-President, in the chair, declared the following duly elected:—

PRESIDENT.

SIR ROBERT KANE, LL.D., F. R. S.

COUNCIL.

Committee of Science.

E. Perceval Wright, M.D., F.L.S; David Moore, Ph. D., F. L. S; John Casey, LL.D., F. R. S; Thomas Hayden, M. D; Rev. J. H. Jellett, B. D., S.F.T.C.D; Alexander Carte, M.D., F. L. S; William Archer, F. R. S; R. S. Ball, LL.D., F. R. S; J. E. Reynolds, M.D.; B. B. Stoney, M. A., C. E; Rev. S. Haughton, M. D., F. R. S.

Committee of Polite Literature and Antiquities.

J. K. Ingram, LL.D; W. J. O'Donnavan, LL.D; A. G. Richey, LL.D.; J. R. Garstin, LL.B., F. S. A.; Very Rev. Dr. Reeves, D.D.; Rev. Thaddeus O'Mahony, D.D.; Lord Talbot de Malahide, F.R.S.; Robert Atkinson, LL.D.; Thomas Drew, M. A., C. E.; S. Ferguson, LL.D.

The Scrutineers having reported, the Vice-President declared Señor Don Augusto Soromenho duly elected an Honorary Member.

Sir Robert Kane, the President elect, having taken the Chair—

The Ballot was then opened for the election of Officers; and the

MONDAY EVENING, JUNE 11, 1877.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Rev. J. P. Mahaffy, M. A., F.T.C.D., read a Paper "On recent Excavations in Greece."

Professor A. Leith Adams read the first part of a Monograph "On Irish Fossil Mammals."

[This paper will appear in the "Proceedings," Second Series, Vol. III., Science, Part 1.]

Read the following letter from E. Perceval Wright, M.D., to the President, resigning the office of Secretary to the Academy.

"TRINITY COLLEGE, DUBLIN,
"*May* 25, 1877.

"DEAR MR. PRESIDENT,

"I have with regret come to the fixed conclusion that it is expedient that I should resign the office of Secretary to the Academy.

"The Editing of the Academy's Scientific Publications demands too great a sacrifice of my time, already too much occupied, and prevents me from devoting as much of it as I could wish to original research, and this might well serve as my excuse; but I confess that, in addition, I am not satisfied with the existing state of affairs in our body, and I believe that the nominal conduct thereof would, at the present crisis, be better in other hands.

"My election to the office I now resign I shall always regard as the highest reward the Members of the Academy could have given to my Scientific work, and for that reward I thank them. I have also to thank you Mr. President, for your unvarying courtesy, and to subscribe myself,

"Most faithfully yours,
"EDWARD PERCEVAL WRIGHT."

"SIR R. KANE, LL.D., F.R.S.
President, Royal Irish Academy."

It was unanimously Resolved—

"That the Academy receives with regret the resignation of Dr. Wright, and desires to place on record its sense of the valuable services rendered by him during his tenure of office, especially on the prompt publication in the Transactions and Proceedings of the Papers read before the Academy."

MONDAY EVENING, JUNE 25, 1877.

SIR ROBERT KANE, LL.D., F. R. S., President, in the Chair.

Dr. Robert S. Ball, F. R. S., Astromoner Royal for Ireland, was ted Secretary of the Academy, in place of Dr. E. Perceval ight, F.L.S., resigned.

Mr. W. H. Baily, read a Paper "On Fossils of the Irish Coal trict (Report)."

By permission of the Academy, Mr. William Plunkett, F.C.S., l a Report by himself and Launcelot Studdert, LL.D., "On Solid and Gaseous Constituents of the Spa, at Mallow, Co. Cork."

[This Paper will appear in the "Proceedings," Vol. III., Second es, Part 1, Science.]

By permission of the Academy, Mr. C. C. Hutchinson read a Paper imself and Mr. A. H. M'Alpine, "On the Gaseous Constituents of Vartry and Royal Canal waters."

This Paper will appear in the "Proceedings," Vol. III., Second s, Part 1, Science.]

By permission of the Academy, Professor Galloway read a Paper essrs. Reginald Laurence, and C. W. Reilly, "On the Albuminoid ers, Alcohol and Phosphates, in the Burton Ales and Dublin r."

y permission of the Academy, Mr. Thomas Bayley read a Paper the Volumetric Estimation of Chromium."

[This Paper will appear in the "Proceedings," Vol. III., Second s, Part 1, Science.]

y permission of the Academy, Mr. Thomas Bayley read a Paper the Peroxides of Cobalt and Nickel."

y permission of the Academy, a Paper by Mr. Henry Hatfield ead "On a Method for the detection of Cadmium in the presence pper."

e Treasurer laid on the Table the following Abstract of the my's Accounts for the year ending 31st of March, 1877, as d by the Rev. Samuel Haughton, M. D., and William r, F.R.S., Committee of Audit.

e Academy then adjourned until November.

ROY[illegible]

GENERAL ABSTRACT OF THE ACCOUNT OF JO[illegible]

FOR THE [illegible]

RECEIPTS.	For Special Purposes.	For General Purposes.
	£ s. d.	£ s. d.
Balance from last Year,	2 1 6	43 15 7
FROM PARLIAMENTARY GRANTS:—		
Unappropriated:—"Old Grant,"	. . .	500 0 0
Appropriated:—		
Preparation of Scientific Reports,	200 0 0	
Library,	200 0 0	
Researches in connexion with Celtic MSS.,	200 0 0	
Publication of ditto,	200 0 0	
Museum,	200 0 0	
Purchase of Treasure Trove,	100 0 0	
Illustration and Printing of "Transactions" and "Proceedings,"	200 0 0	
Opening the Academy in the evening,	137 8 0	
" TRINITY COLLEGE GRANT towards reproduction of the MS. known as the Book of Leinster (on account of £700) making £420,	100 0 0	. . .
" MEMBERS' PAYMENTS:—		
Entrance Fees,	. . .	73 10 0
Annual Subscriptions,	. . .	344 8 0
Life Membership Composition (*invested as opposite*),	90 6 0	
" PUBLICATIONS SOLD:—		
Transactions,	. . .	6 15 6
Proceedings,	. . .	1 1 2
" Irish MSS. Series,	. . .	0 7 0
Leabhar Breac,	. . .	18 5 0
Leabhar na h-Uidhri,	. . .	6 15 0
Photographs of Museum Objects,	. . .	0 11 0
Museum Handbook,	. . .	1 3 0
Museum Catalogue (*invested as opposite*),	5 15 6	
" INTEREST ON INVESTMENTS:—		
Life Composition—Consol. Stock,	. . .	73 8 8
Cunningham Bequest—New 3 per cent. Stock (*see opposite*),	75 11 3	
Museum Catalogue—Bank of Ireland Stock (*see opposite*),	4 5 5	
" TEA FUND Subscriptions,	7 15 0	
	£1723 2 8	1069 19 11

I certify that the above account is correct, according to [illegible]

for An[illegible]

r.

REASURER OF THE ROYAL IRISH ACADEMY,

[, 1877.

PAYMENTS.	From Funds appropriated for Special Purposes.			From Funds available for General Purposes.			Total of each Class.		
	£	s.	d.	£	s.	d.	£	s.	d.
TIFIC AND LITERARY PUR-ES:—									
Literature and Antiquity Objects, .	.	.	.	.	.	.			
lc Reports, ...	200	0	0						
', ...	200	0	0	61	19	0			
cribe, &c., ...	200	0	0	0	8	5			
(including Lithographing eabhar Breac, and Printing Felire ngus, Part I.), ...	200	0	0						
n, ...	200	0	0	30	11	3			
e Trove	100	0	0	36	0	6			
tions and Proceedings, ...	200	0	0	196	13	4			
g the Academy in the evening, . .	137	8	0						
gham Prizes, ...	20	0	0						
f Leinster, ...	93	12	0				1849	12	6
LISHMENT CHARGES:—									
, ...	.	.	.	404	0	0			
and Liveries, ...	.	.	.	208	5	6			
. . . .	.	.	.	21	15	0			
ce, Taxes, and Law, ...	.	.	.	8	2	6			
ry, ...	.	.	.	10	9	0			
g (Miscellaneous), ...	.	.	.	43	13	11			
, ...	.	.	.	27	8	5			
s, Incidentals, and Contingencies, .	.	.	.	30	17	7	754	11	11
'MENTS (CAPITAL):—									

	Stock Bought. £	s.	d.	Description.	Total Stock. £	s.	d.	£	s.	d.						
ip . .	93	2	1	Consol. Stock,	2572	0	2	90	6	0						
le-st, .	58	0	0	New 3 per Cents,	2618	0	5	55	11	3						
gue,	3	2	6	Bk. of Ir. Stock,	40	5	10	10	0	11				155	18	2

	£	s.	d.	£	s.	d.	£	s.	d.
IND Expenditure, ...	7	15	0	12	17	1	20	12	1
	£1714	13	2	1066	1	6	2780	14	8
Balance to Credit of the Academy,	8	9	6	3	18	5	12	7	11
	£1723	2	8	1069	19	11	2793	2	7

l belief, JOHN RIBTON GARSTIN, *Treasurer, R.I.A.*

AUDITORS' REPORT.

We have examined the above General Abstract, and compared the the details of the several heads thereof, and find the same to be corr Balance of Twelve Pounds Seven Shillings and Eleven Pence to the Academy; which amount is certified by the Accountant-General mained to the credit of the Academy's account in the Bank of Ireland March, 1877.

The Treasurer has also exhibited to us like Certificates in r invested *Capital*, showing that the amounts of Stock standing in the Academy on the same day were £2618 9*s*. 5*d*., New Three £2572 0*s*. 2*d*., Consols; and £40 5*s*. 10*d*., Bank of Ireland Stock.

(Signed), SAMUEL HAUGHTON, }
WILLIAM ARCHER, }

21*st of May*, 1877.

Royal Irish Academy.

MINUTES OF PROCEEDINGS.

MONDAY EVENING, NOVEMBER 12, 1877.

SIR ROBERT KANE, F. R. S., President, in the Chair.

The following Papers were read:—

"On the Colour, Relations, and Colorimetric Estimation of Nickel and Cobalt." By Thomas Bayley, Esq. [Vide *Proceedings*, vol. iii., ser. ii., part 2.]

"On a Comparison of the Observed and Calculated Heights of High Water at Fleetwood, from the 8th August, 1876, to the 9th October, 1877." By Rev. James Pearson, M. A. [Vide *Proceedings*, vol. iii., ser. ii., part 2.]

"On Sculptured Fragments of Bone from the Tumuli at Slieve-na-Calleagh." By E. C. Rotherham, Esq.

"On Observations of the Parallax of the Planetary Nebula. H. IV. 37." By Dr. Brünnow. [Vide *Proceedings*, vol. iii., ser. ii., part 2.]

Donations were presented, and thanks voted to the several donors.

STATED MEETING, NOVEMBER 30, 1878.

SIR ROBERT KANE, F. R. S., President, in the Chair.

The Secretary of Council reported that the Council had taken steps towards the entertaining by the Academy of the British Association, during their meeting in Dublin, at a Conversazione; and that the Lord Mayor had, at the request of the Council, given permission to open a communication between the premises of the Academy and

"That the Academy gratefully acknowle
Lord Mayor in placing the required rooms i
their disposal for the Conversazione to l
Association."

By decree of the Council, Dr. Richey, Q.
a return for the better management of the C
form of a draft letter of instructions to the s

Letter of Instructions to Acade

"Royal
"Daw

"Sir,

"Pursuant to authority for this purp
Council of the Royal Irish Academy, we re
the necessary steps to have a petition on beh
sented to the Court of Chancery, for the purp
cil to apply the surplus of the fund called
to the objects of the Institution.

"The Institution is incorporated for th
Polite Literature, and Antiquities. The C
from a bequest to the Academy, on trust to ap
premiums as they should think proper for the
knowledge and other objects of their Institut

"The Academy have entrusted the admin
the Council.

"The Council is advised that this state of facts gives a legitimate ground to apply for relief under the *cy pres* jurisdiction of the Court of Chancery.

"The history of the Fund and of the endeavours of the Council, from time to time, down to 1861, to apply it to the particular purpose described, will be found at page 406 of the 7th vol. of the *Proceedings* of the Academy, herewith sent. Attention is requested to the statement, at page 417, respecting the disinclination of Members of Council to be themselves competitors, and its consequences.

"Since then, a few medals only have been awarded; and, although subjects for Prize Essays, to the amount of £100, have, within the last three years, been proposed and largely advertised, the Council have not received any Papers to which they could conscientiously award the prize.

"The result is, that the Fund now consists of the principal sum of £1600, in the Report mentioned, with accumulations of interest, amounting together to £2560 9*s.* 5*d.* of New Three per Cent. Stock.

"The Council are much pressed for funds to defray the necessary charges of printing their *Transactions* and *Proceedings*, which, though not coming directly within the language of the trust, are meritorious works, the publication of which tends to the promotion of the general objects of the Testator.

"You will, therefore, be pleased to take the necessary steps for obtaining the authority of the Court of Chancery that the Council, after providing for such premiums as may, from time to time, appear well merited and calculated to promote the particular objects of Testator, may apply the interest of the Cunningham bequest generally in aid of the objects of the Academy, viz., in promoting the study of Science, Polite Literature, and Antiquities, or otherwise as to the Court shall appear proper.

"It occurs to us that the proceedings should be under Lord Romilly's Act, and that the petition need not go into much detail.

"We are, Sir,

"Your obedient servants,

"ALEXANDER GEORGE RICHEY (*per* S.F.)

"SAMUEL FERGUSON, V. P.

"ARTHUR BARLOW, Esq., *Solicitor*,

"*North Great George's-street, Dublin.*"

It was Resolved—

"That the several proceedings of Council relative to the Cunningham Fund, commencing December 12, 1875, the petition in this matter, and the draft letter of instruction be printed, and a copy thereof be sent to each and every of the Members; and that the subject-matter of said letter of instruction be taken up by the Academy at its meeting of the 14th January, 1878."

MONDAY EVENING, DECEMBER 10, 1877.

SAMUEL FERGUSON, LL. D., Vice-President, in the Chair.

Charles Smith, Esq., Barrow-in-Furness, was elected a Member of the Academy.

The following Papers were read:—

"On Schutzenberger's Process for the Volumetric Estimation of Oxygen in Waters." By C. C. Hutchinson, Esq. [Vide *Proceedings*, vol. iii., ser. ii., part 2.]

"Observations on Double Stars." By Dr. Brünnow.

MONDAY EVENING, JANUARY 14, 1878.

SIR ROBERT KANE, F. R. S., President in the Chair.

Read, the following letter from the Science and Art Departm of 21st December, 1878.

"SCIENCE AND ART DEPARTMENT,

"SOUTH KENSINGTON, S. W

"21*st December*, 1877.

"SIR,

"It was stated in the letter of the Vice-President of the (mittee of Council on Education, dated the 8th of February, 187(the subject of the formation of a Science and Art Museum in Irel that their Lordships earnestly desired to retain the advantage of assistance and authority which the continued co-operation of Societies with the Government, in this more extensive national

MONDAY EVENING, JANUARY 28, 1878

SIR ROBERT KANE, F. R. S., President, in th

The Rev. J. H. Jellett, B. D.; Samuel Ferguson, Robert Kane, F. R. S. (President), were elected Mem of Visitors of the new Science and Art Museum in D

It was moved by the Secretary of Council—

"That the Draft Scheme for the administration ham Fund, submitted at the Stated Meeting of the last, be adopted by the Academy."

DRAFT PETITION.

"*In Chancery.*

"In the Matter of the ROYAL IRISH ACADEMY, and the 52nd George 3rd, cap. 101, intituled 'An summary remedy in case of abuse of trusts crea purposes.'

"*To the* Right Honorable JOHN THOMAS BALL, LORD OF IRELAND.

"The Petition of SAMUEL FERGUSON, of No. 20 North street, in the city of Dublin, Esq., Q.C., and A RICHEY, of 27 Upper Pembroke-street, in the city Q.C., two of the members of the Council of the demy,

"HUMBLY SHOWETH,

should think proper, for the improvement of natural knowledge and other objects of their Institution, and the said Testator thereby appointed the Rev. Thomas Hussey sole Executor of his said Will.

"2. The said Timothy Cunningham died shortly afterwards, and his said Will was duly proved in London on the 16th June, 1789, and Probate thereof granted to the said Rev. Thomas Hussey, the Executor named.

"3. The Royal Irish Academy was incorporated by Royal Charter in the year 1786 for promoting the study of Science, Polite Literature, and Antiquities.

"4. The legacy of £1,000 was duly paid over to the said Royal Irish Academy.

"5. Under the Statutes and By-laws of the Academy all medals or other honorary rewards are from time to time to be awarded by the Council of the Academy at their discretion.

"6. Different plans have from time to time been adopted for the purpose of carrying out the intentions of the said Testator.

"7. The first plan was that of giving prizes for the best essays on subjects proposed by the Academy.

"8. This was soon afterwards altered, and 'The Cunningham Gold Medal' was instituted instead of a pecuniary prize.

"9. These Medals were for some time given for papers published in the *Transactions* of the Academy, but this plan was objected to, as narrowing too much the field of competition and diminishing in proportion the honour of the reward.

"10. In the year 1848 a new plan was substituted, which was as follows:—

"I. All Works or Essays in the departments of Science, Polite Literature, or Antiquities, which should be published in Ireland, whether in the *Transactions* of the Academy or not, or which should relate to Irish subjects, were to be considered as competing for the Medal.

"II. The Council of the Academy were to award Medals every third year, and were to take into consideration all papers or works coming under this description which had been published within the six years preceding.

"III. Money premiums were, from time to time, to be given for Essays or Reports on stated subjects.

"11. These regulations have been only partly acted on, the limits of time having been found inconvenient, and the regulations in that respect being deemed improvident, a further resolution was passed at a meeting of the Council of the Academy on 18th November, 1872, by which the said regulations of March, 1848, respecting the medals and premiums from the Cunningham Bequest, were repealed, and it was resolved that awards from it thereafter should be made at the discretion of the Council, limited only by the Trusts of the Testator's Will.

"12. Subsequently, on the 3rd February, 1873, a further resolution was passed by the Council of the Academy, by which the Council agreed to recommend the Academy to offer out of the Cunningham Fund two premiums of £50 each for Essays on the then present state of the Irish Language and Literature, written and unwritten, in Munster and Connaught.

"13. This recommendation was subsequently adopted at a General Meeting of the Academy, held on the 16th March, 1873.

"14. Seven Essays were sent in, but their merit being insufficient to entitle any of them to the full amount of a prize, the Council decided to divide £50 between three of the Essayists.

"15. In December, 1874, the Council offered two premiums of £50 each for the best Reports or Essays on the then present state of the Irish Language and Literature, written and unwritten, in the Provinces of Leinster and Ulster respectively.

"16. Three Essays were sent in, but none were of sufficient merit to entitle the author to a full prize; however, £20 was awarded to one of the Essayists.

"17. The Council have awarded no premiums since the year 1874.

"18. Notwithstanding the desire of the Council to give premiums, they have found that that form of encouraging learning out of said Cunningham Fund has not been successful, and that the interest of the Fund has outgrown their ability to apply it beneficially in that way.

"19. The Council are desirous that a scheme should be devised, so as to enable the Royal Irish Academy to employ the interest on the Cunningham Fund in the most advantageous and beneficial manner.

"20. The present Members of the Council of the Academy are:—

President:

SIR ROBERT KANE, M. D., F. R. S.

The Council:

Elected.
). Mar. 1870. Edward Perceval Wright, M. D., F. L. S., F. R. C. S. I.
). „ 1872. David Moore, Ph. D., F. L. S.
). „ 1872. John Casey, LL. D., F. R. S.
). „ 1873. Thomas Hayden, F. K. & Q. C. P. I., F. R. C. S. I.
). „ 1874. Rev. John Hewitt Jellett, B. D., S. F. T. C. D.
). „ 1875. Sir Robert Kane, M. D., LL. D., F. R. S., F. K. & Q. C. P. I.
). „ 1875. Alexander Carte, M. D., F. L. S., F. R. C. S. I.
). „ 1875. William Archer, F. R. S.
). „ 1876. Robert Stawell Ball, LL. D., F. R. S. (*Sec.*)
). „ 1876. James Emerson Reynolds, M. D., F. C. S.
). „ 1870. Rev. Samuel Haughton, M. D., F. R. S., D. C. L., F. T. C. D.
). „ 1877. Bindon B. Stoney, C. E.
). „ 1859. John Kells Ingram, LL. D., F. T. C. D.
). „ 1867. William John O'Donnavan, LL. D.
). „ 1869. Alexander George Richey, LL. D., Q. C.
). Dec., 1869. John Ribton Garstin, M. A. & LL. B., F. S. A.
). Mar. 1871. Very Rev. William Reeves, D. D., LL. D., M. B.
). „ 1873. Rev. Thaddeus O'Mahony, D. D.
). „ 1875. Rev. Maxwell Close, M. A.
). „ 1875. Robert Atkinson, LL. D.
). „ 1876. Thomas Drew, R. H. A.
). „ 1867. Samuel Ferguson, LL. D., Q. C.,

whom your petitioners are two.

"21. The whole interest on the Fund constituting the Cunning-m Bequest, not having been expended from time to time in :miums and medals, the present amount of the said Fund, includ-; principal and the interest from time to time added thereto, is the n of £2618 9*s.* 5*d.* Government new Three per cent. stock, which is w standing in the books of the Governor and Company of the Bank Ireland, in the name of the Royal Irish Academy.

"22. The funds available for the publication of the *Transactions* l *Proceedings* of the Academy are not sufficient for that purpose, l many Papers of merit are held over, for want of adequate means their publication.

"23. Your Petitioners submit that the interest on said Cunningham quest might be usefully employed, after providing for such pre-ums and medals, if any, as from time to time the Council may see to award, by applying it from time to time in aid of the funds at the

AFT OF PROPOSED INSTRUCTIONS FOR THE PREPARATION OF A SCHEME.

'he order of his Honour the Master of the Rolls, dated the 19th ber, 1877, and made in the matter of the Royal Irish Academy e matter of the 52nd Geo. 3., chap. 101, has been laid before, refully considered by, the Council of the Royal Irish Academy. Iis Honor by such order has directed that the Petitioners bring in and lodge in his Chambers a draft of a scheme, and ich scheme should be settled by Counsel, and that a copy of cheme should be lodged with the Clerk of the Attorney-l.

'he Petitioners in the matter presented the petition at the t and by the directions of the Council, and are, both they and uncil, desirous that such a scheme should be presented to the as may meet the views of the Counsel employed in this case, lso the wishes of the general body of the members of the ny.

'he Council has, therefore, taken the opinion of the members of ademy as to the nature of the proposed scheme, and have re- their consent and approval to the following instructions. It is Counsel employed to reduce these instructions to a formal and al shape; and these instructions are, therefore, intended merely xpression of the wishes of the Council and the Academy as to bstance and matter of the scheme.

'he Council and the members of the Academy desire that the t and dividends of the Cunningham Fund should be applied in nner following :—

ı premiums of an honorary nature, such as medals, &c., to persons rendering eminent services in Science, Polite Literature, or Antiquities.

ı pecuniary premiums, to be awarded by the Council for the est Essays upon subjects to be proposed by the Council, when nd as they think fit, and advertised for public competition.

ı the publication, under the title of 'Cunningham Prize Memoirs,' of such Papers read before the Academy as in the opinion of the Council of the Academy possess eminent merit.

"4. That, subject to the making due provision for the above purpo
Council be at liberty to apply the annual revenue and divi
towards the expenses of the publication of the *Trans*
and *Proceedings* of the Academy.

"5. That for all or any of the purposes aforesaid, numbered re
tively 1, 2, and 3, the Council be at liberty to have recou
the present or future accumulation of dividends, and to
with the same as the revenue of the current year.

"You are requested to lay these instructions before Counsel f
guidance in the preparation of the proposed scheme."

After a prolonged debate,

It was Resolved—

"That the further consideration of the subject be adjourn
the next night of meeting."

MONDAY EVENING, FEBRUARY 11, 1878.

SIR ROBERT KANE, F. R. S., President, in the Chair.

Charles E. Burton, A. B.; George F. Fitzgerald, M. A.; I
W. Lowry, B. A., and Michael O'Hanlon, M. D., were e
Members of the Academy.

The consideration of the Cunningham Fund Scheme w
sumed, and the following amendment was adopted:—

"That the Academy accept the scheme proposed by the C
for the better administration of the Cunningham Fund, subj
such alterations (if any) as, on discussion of its details, shall se
and that the Academy now proceed to consider the scheme, par
by paragraph, as set out in the draft of proposed instructions
Council have placed before them."

The adoption of the first paragraph of the Report of C
having been moved, the following amendment was move
seconded:—

"That the first clause shall have the words within brac
follows inserted therein:—

"I. In premiums of an honorary nature, such as Medals,
[One in every year to the author of the best Paper read bef
Academy during the previous three years, in one of the fol

ts, in rotation, viz.:—(1) Pure Science, (2) Applied Science, olite Literature and Antiquities; and] to persons rendering nt services in Science, Polite Literature, or Antiquities."

e amendment having been negatived, the following amendment en proposed and seconded :—

In premiums of an honorary nature, such as Medals, with or ut pecuniary premiums, to persons rendering eminent services in e, Polite Literature, or Antiquities."

this was added the words, "which premiums shall be awarded ially."

division having taken place, the amendment was negatived, and st clause of the Draft Scheme was adopted by the Academy.

e second, third, fourth, and fifth clauses were carried unani- y.

e final clause—"You are requested to lay these instructions Counsel, for his guidance in the preparation of the proposed e"—was carried unanimously.

e preamble having been accepted, the entire draft was then d by the Academy.

MONDAY EVENING, FEBRUARY 25, 1878.

SIR ROBERT KANE, F. R. S., President, in the Chair.

e following Papers were read :—

A Chemical Examination of the Mixed Waters of the Estuary of iver Liffey, with Remarks on the Discharge of Sewage into ries," By L. Studdert, LL. D.

On a Unique Copy of the Life of the Virgin, by Albert Durer." illiam Frazer, M. D.

Further Remarks on the Supposed Substitution of Zinc for esium in Minerals." By E. T. Hardman, F. C. S. [Vide *Pro- gs*, vol. iii., ser. ii., part 2.]

On the Acanthology of the Desmosticha," Part I. By H. W. intosh, B. A. [Ordered for *Transactions*, vol. xxvi.]

On Direct Demonstration of the Properties of the First Negative of a Central Conic from any Point on its Plane." By J. C. , M. A. [*Transactions*, vol. xxvi., part 12.]

SATURDAY EVENING, MARCH 16, 1878.

(Stated Meeting.)

SIR ROBERT KANE, F. R. S., LL. D., President, in th

The Ballots for President, and Members of Council, and for Honorary Members, being opened, the Preside J. J. Digges La Touche, William Frazer, M. D., Profess and The O'Conor Don, M. P., Scrutineers for the election Council, and Officers; and W. J. Fitzpatrick, LL. D., Neville, C. E., as Scrutineers for the election of Honorar

The Secretary of Council brought up the following Council for the year 1877–8:—

REPORT OF COUNCIL FOR THE YEAR 1877–8.

Since the date of the last Report of the Council, t parts of vol. xxvi. of the *Transactions* have been publish

Part 7. "The Red Stars: Observations and Catalo Birmingham.

Part 8. "On a New Species of Parasitic Green Alga the genus Chlorochytrium of Cohn." By E. Perceval W

Part 9. "On a Species of Rhizophydium parasitic Ectocarpus, with Notes on the Fructification of the Ect E. P. Wright, M. D.

Part 10. "A Supplement to Sir John Herschel's 'C logue of Nebulæ and Clusters of Stars.'" By J. L. E. D F. R. A. S.

And the following is in the press:—

Part 11. "On the Aspect of Mars at the Oppositions 1873. By C. E. Burton."

Of our *Proceedings* there have been issued within the y vol. iii. (second series), containing Papers on Science; of vol. i. (second series), containing Papers on Polite Lit Antiquities.

Within the past year, Papers by the following autho before the Academy:—

In the department of Science:—by Professor Tait; S. Ball; Dr. C. R. C. Tichborne; Professor E. P. Wright

r; Rev. James Pearson; Professor A. Leith Adams; Mr. W. ey; Dr. Brünnow; Mr. Edward T. Hardman; Mr. H. W. osh; Mr. J. C. Malet; Mr. Thomas Bayley; Mr. Henry Hat- Ir. Wm. Plunkett and Dr. Lancelot Studdert; Mr. C. C. Hut- and Mr. A. N. M'Alpine; Mr. Reginald Lawrence and Mr. C. ly.

he department of Polite Literature and Antiquities:—by Mr. rofton; Dr. Samuel Ferguson; Rev. J. P. Mahaffy; Mr. E. C. m; and Dr. W. Frazer.

work of lithographing the most valuable of our Irish MSS. teady progress. Of the "Book of Leinster," 312 pages, being an three-fourths of the whole, have been printed off, and 80 al pages are on stone. The Irish scribe pursues his work with ble diligence, and it is expected that the remaining portion completed before the summer of 1879.

whole of the triple text of the Felire of Oengus having inted, Dr. Whitley Stokes applied for and obtained the con- the Council to have the Glossarial Index, which is to be printed in Calcutta, with a view to save the time lost in the ssion of proofs between this country and India. It appeared, r, on trial, that the work could not be properly executed there. manuscript of the Index is now in the printer's hands, and a ortion of it is in type; and the issue of the entire work may be d in the course of the present year.

question pending between the Academy and the Government nsiderable time prevented progress being made in the publica- the *Annals of Ulster*. This difficulty having been removed, ments have been made for the immediate commencement of the g, and it is hoped that the Council will be able, in their next , to announce that a substantial portion of the work has been ted.

eral interesting objects have been added to the Museum within r. Amongst those procured by purchase are a very fine lunula , a torque of the same metal, and some weapons of bronze. The ns include an ancient canoe and a singular trough-shaped vessel sepulchral urns, and other articles, presented by Mr. J. G. V. of Belleisle. For the Strong Room a movable mahogany case has been constructed, in which will be deposited some of

£25 to C. R. C. Tichborne, F. C. S., for Research
ral diffusion of Fluorine in Animal Concretions, &c.

£25 to E. T. Hardman, F. C. S., for Apparatus
enable him to continue his Chemico-Geological Rese

£20 to A. G. More, F. L. S., for the Examinatio
the South and West of Ireland.

£12 to A. Leith Adams, F. R. S., towards the exp
materials relating to the Natural History of the Iri
view of producing a Monograph on the subject.

£18 to Rev. J. H. Jellett, B. D., for Researches
between Light and Electricity.

£70 to Professor Oswald Heer of Zurich, for an
the Tertiary Flora of Antrim.

£30 to Dr. Macalister, for purchase of rare specin
Embryological Researches.

The Council thought it their duty to address a
Lord President of the Committee of Council on Educa
attention to the composition of the Committee for the
the grant of £4000 now annually voted by Parliame
ragement of Scientific Research, and urging the inad
presentation of Ireland on that body. In taking this
in conjunction with the Royal Society of Edinburgh,
porting a similar claim put forward by that learned b
prayed that this Academy should have in future two
on the Committee, instead of one, as had been previou

The Academy was recently invited by the Lords of the Committee of Council on Education to nominate three persons to act as Members of the Board of Visitors, constituted, in accordance with Lord Sandon's letter of the 8th of February, 1876, to aid their Lordships in the administration of the new Science and Art Museum to be founded in Dublin, as well as of the Natural History Collections and the Botanic Gardens, which are to be associated with that establishment. The Academy accordingly nominated the Rev. John H. Jellett, Samuel Ferguson, LL. D., and Sir Robert Kane, to act on the Board.

A proposal was made to the Council of the Academy in April last by the Council of the Royal Dublin Society for a Conference between the President and Science Committee of the Academy and twelve members of the Royal Dublin Society, whose names were given, to consider certain suggestions which had been made by a Committee of the Royal Dublin Society, the most important of which was, that "it would be desirable that a Society devoted *exclusively* to Science should exist in Dublin." A correspondence between the two Councils took place on the subject, the result of which was, that the Council of the Royal Dublin Society declined to accept the Conference under the conditions which the Council of the Academy thought it necessary to prescribe. The correspondence is given in an Appendix to the present Report, which also contains a letter which the Council thought it their duty to address to the Secretaries of Her Majesty's Treasury, in relation to one of the heads of agreement between the Government and the Royal Dublin Society, embodied in the Memorandum of Provisions agreed to on the 5th of March, 1877.

It is known to the Members of the Academy that the British Association for the Advancement of Science will hold its next meeting in Dublin, in August of the present year. The Council of the Academy, at the request of the Lord Mayor, nominated several gentlemen to act on the Local Committee appointed to make arrangements for the reception of the Association. The Academy has also resolved, on the suggestion of the Council, to give a Conversazione on the occasion, as it did when the Association last visited Dublin. A subscription amongst the Members of the Academy has accordingly been opened. The Reception Committee of the Association has offered to place £100 at our disposal towards the requisite expenses. It is understood that all Members of the Association, as well as Members

in the scientific world.

The re-transfer of the charge of the Academy's the Science and Art Department to the Chief Secret been carried into effect, in accordance with the arr into with the Government.

The Treasurer reports that there is no feature Academy's finances calling for special remark, an that the accounts for the year ending on the 31st o be found satisfactory.

The Council, dissatisfied with the past administr ningham Fund, and desirous that it should be u ample manner for the promotion of the principal testator had in view, caused to be prepared a Draft be given for the preparation of a scheme to be laid of the Rolls, for the better administration of the F was submitted to the Academy, with the Resolutio and other documents relating to it, and, after a pro was adopted by the Academy.

It is the opinion of the Council that too long an allowed to elapse without an award of medals out o Fund, and they recommend this subject to the cons successors.

Nine ordinary Members have been elected since 1877, viz. :—

1. Rev. G. H. Reade, M. A.
2. Francis A. Tarleton, LL. D.

8. R. W. Lowry, B. A.
9. M. O'Hanlon, M. D.

We have lost by death within the year seven Honorary Mem-
rs :—

In the department of Science :—

1. Urbain Jean Joseph Leverrier.
2. Henri Victor Regnault.
3. Padre Angelo Secchi.

In the department of Polite Literature and Antiquities :—

1. John Lothrop Motley,
2. John Stuart,
3. Augusto Soromenho,
4. Louis Adolphe Thiers,

nd eleven Ordinary Members, viz. :—

1. C. Neville Bagot, elected June 8, 1863.
2. Edward Cane, elected February 22, 1836.
3. Fleetwood Churchill, M. D., elected January 10, 1842.
4. Eugene A. Conwell, LL. D., elected January 9, 1860.
5. Denis H. Kelly, elected June 24, 1838.
6. Thomas F. Kelly, LL. D., elected January 25, 1836.
7. James C. F. Kenney, elected April 10, 1848.
8. John Mollan, M. D., elected January 13, 1840.
9. Thaddeus M. O'Callaghan, C. E., elected January 11, 1876.
10. William Stokes, M. D., elected November 29, 1834.
11. Henry Wilson, F. R. C. S. I., elected January 8, 1866.

Amongst these names, that of William Stokes naturally takes the remost place. He was born in Dublin in the year 1804. He belonged a family in which, as has been well said, "genius is hereditary." is father, Dr. Whitley Stokes, was a man of great ability and origi-lity of intellect; and his honesty and independence of character re shown by his resignation, for conscientious reasons, of his Senior llowship in Trinity College. On his retirement from that office, he as appointed Lecturer in Natural History—a post which he filled ll he became Regius Professor of Physic in 1830. With his scientific

[illegible]

[illegible] exhaustive examination of every [illegible] treatment marked [illegible] presented to the student the perfect [illegible] As a lecturer he possessed very [illegible] the earnestness of manner [illegible] impressive; and he had that special power [illegible] in his teaching which belongs to the [illegible]

Already in 1825, when he was but twenty-one years of age, had ppeared his first contribution to medical literature—his *Introduc-ion to the Use of the Stethoscope*, founded on the works of Laennec nd Andral, but containing much original matter, and giving clear romise of his future eminence. This work was followed, in 1828, by wo lectures "On the Application of the Stethoscope to the Diagnosis and Treatment of Thoracic Disease." At this time the new instru-ment was far from having obtained general acceptance amongst the members of the profession. But Stokes caught up, with enthusiasm, the additional resource which had been placed at the disposal of the hysician, declaring that "it had added more to the facility, cer-ainty, and utility of diagnosis than anything that had been done for nturies."

Very soon after his appointment to the Meath Hospital he began contribute to the medical periodicals of the day. Many Papers of s appeared in the *Dublin Hospital Reports*, the *Dublin Hospital azette*, the *Transactions* of the Association of the College of Physi-ians, and in the *Dublin Journal of Medical Science*, which, at first dited by our President, Sir Robert Kane, was afterwards, for several ears, conducted by Graves and Stokes. Some of his communica-ions to the last-named Journal were in the form of Reports of the Pathological Society, which had been founded by Stokes in con-junction with the late Professor R. W. Smith; others were of the nature of Reviews, amongst which may be particularly mentioned his otice of Calmeil's *Treatise on Insanity*, in which he points out the elations between the phenomena of the mesmeric state and those xhibited in the nervous epidemics which have appeared more than nce in medieval and modern Europe.

In 1837, Dr. Stokes published the first of his great medical works —his *Treatise on the Diagnosis and Treatment of Diseases of the Chest*. This work at once established his reputation as standing in the fore-most rank of clinical observers. It was received by the profession at ome and abroad as a most valuable contribution to science; and onorary distinctions were conferred on its author by many medical ocieties on the Continent of Europe and in America. In 1854 ap-peared his work *On Diseases of the Heart and Aorta*, which took similar ank with its predecessor in the estimation of the medical world. So late as 1874, completing the Triad of Classical Treatises from his

Theatre of the Meath Hospital or in the Univer
which, in the year 1845, he succeeded his father
of Physic. These are to an unprofessional reader t
his varied powers, and a most interesting record of
He exhibits in them the attitude which all throug
tained in relation to the philosophy of medicine. "
he said, "a Theory of Medicine. But at the appoin
required amount of facts have been faithfully obse
they will, by one of the great properties of truth
taneously into a system and a law." He was, acco
doctrine what he described Graves as having been—
essentially following the Hippocratic tradition, and
primary importance to the study of symptoms in th
denying the connexion of all disease with organic lesi
vast advantage which had arisen from the research
cal anatomists. He welcomed all the additions con
science to the means of diagnosis, proclaiming—as
the very outset of his career the importance of steth
of his latest discourses enumerating the aids to be d
from new applications of acoustics, and from ph
generally, in the study of morbid conditions.

But in these Addresses he has also dealt with que
kind, and of no less importance to the public; an
largely occupied his mind, and his views respecting
put forward in his public and private discourse, t
passed over in a notice like the present. Filled with

its full fruit, not merely on account of the various contacts now lished between medicine and the whole range of the sciences, but use, for the true physician, what is above all things needed is the eptive habit of mind which a large and liberal education is fitted to produce. "Medicine," he said, "is not a handicraft, rned by a fixed rule, or any set of rules that you can learn by rote. not a study of fixed, but of varying conditions." Hence, he in-d, that to deal with it the mind must have the suppleness and rce which will enable it to adapt itself to complex phenomena, enting from time to time new characters and varied combina- And though no system of education will give the sensus medicus, seems to be a gift of nature, it is evident that a general cultiva-f the powers of the mind, and rational habits of observation and tion, must be the best preparation for so difficult a task.

urther, believing it to be important for mankind that the al profession should occupy a high place in public opinion and in y, he dwelt on the necessity of a good general education with a o this result also. He urged, that without such an education the sion would tend to degenerate into a trade, and the worst of ; and that men whose general powers of mind had not been cul-d, whose tastes were unrefined, and who were strangers to wide portant fields of knowledge, could not maintain the dignity profession, or assert for it the position which it is entitled to

a similar spirit he preached the necessity of moral training. e aimed at elevating the moral tone of the students who came his influence; and, remarkable as he always is for the fresh-nd force of his style, he sometimes rises into a strain of genuine nce when he paints the ideal physician, and enlarges on the and responsibilities of a profession whose labours are a perpe-xercise of humanity, and in which, to use his own words, our is so indispensable and so precious that he who wants it, or as soiled it, has no business there."

r was he less zealous for the material interests of his medical en, especially of those who were least able to vindicate their laims. He made an effort to procure for such of them as were ith the Poor-law service some fitting recognition of their of the dangers to which they were exposed. He and

Mr. Cusack gave remarkable evidence before a Committee of the House of Commons in 1843, on the excessive mortality amongst Irish practitioners, especially from the prevalence of typhus fever in this country. A demand, based on these considerations, was made for an improvement in their pecuniary position, which was partially—though unhappily only partially—successful.

Dr. Stokes always protested against what he calls "the unhappy and calamitous division of the profession into medicine and surgery." Sooner or later, he held, that factitious and unreasonable distinction would be obliterated. "The human constitution," he says, "is one; there is no division of it into a medical and surgical domain; the same laws and the same principles apply to the cure of a fractured bone and the cicatrisation of an internal ulcer." What he regarded as most essential, however, was not the fusion of the two branches of the profession, though to this he looked forward, as likely both to further the progress of science and to elevate the moral and political status of the profession, but the fundamental identity of the education of both. Advantages, as he says, no doubt arise from a practitioner devoting himself to this or that branch; but, if he seeks for eminence, he will first educate himself generally. Especially he dwells on the necessity to the surgeon of a thorough study of fever, from which more men in the British Navy died during the great French War than from all other causes, including the sword. It is, without doubt, in a great measure to the influence and arguments of Stokes that we owe the marked movement in the Dublin School towards an identical training for the physician and the surgeon.

Dr. Stokes foresaw and predicted the increasing degree in which the medical profession would be brought by the demands of modern civilization into relation with the Government of the country. In particular, as he points out, the growing sense of the importance of sanitary measures, and the gradual development of the central and local organizations for the improvement of the public health, must tend in that direction. It was mainly due to his influence that the University of Dublin established, in 1871, the Certificate of Qualification in State Medicine for such Medical Graduates as have made a special study of the extensive group of subjects included under the name of Preventive Medicine. His views as to the necessity of joint action of the State and the Profession were, in some degree, carried into effect by the creation

of the General Council of Medical Education, of which he was nominated a Member by the Crown, and in whose labours he took an active and influential part.

In 1868 was published *The Life, and Labours in Art and Archæology, of George Petrie.* Connected with that eminent man for many years by the closest ties of friendship, and sympathizing profoundly with his sentiments and tastes, Dr. Stokes was probably better fitted than any other person to be his Biographer; and the book is a worthy memorial of the great antiquary of whom this Academy is justly proud, fully and ably describing his public services, while it paints with life-like truthfulness his gentle and loveable character. But it is much more than a biography: besides abounding in accurate information and just criticism on subjects of Art and Archæology, it gives an account, from several points of view, of that memorable period in our national history which almost deserves the name of the Irish *Renaissance.* It is more than once observed by Dr. Stokes that, during the first quarter of the present century, a noticeable apathy had come over the Irish mind; there was a marked decline of intellectual vitality and initiative. But the twenty years that followed form, he says, "the most remarkable, and not the least glorious, epoch in our history;" for it was then that a singular development of intellect and energy in almost every department of mental culture showed itself amongst us. "It was the time," he adds, "of Hamilton, the younger Lloyd, Lord Rosse, MacCullagh, Apjohn, and Robinson; in literature, of Todd, Anster, Butler, Hincks, and Petrie; in medicine, of Graves, the representative man of Irish medical science, and of many more whose labours in various paths of original investigation have advanced the honour and interests of their country." The re-awakening was felt in the University, which then began the series of reforms which has so much improved and expanded its entire system; in the Clinical teaching of the Medical School of Dublin—a School which rose into distinction with unexampled rapidity; in general and periodical literature; but nowhere was the new life which then began to stir more active than in this Academy, as the list of names we have quoted will sufficiently show. This great period is not indeed described in all its aspects in Dr. Stokes' work, but such figures and incidents as group themselves round Petrie—the movement in archæological study; the Topographical Survey, that noble undertaking, too soon brought to a close; the

increase of the manuscript treasures of the Academy; the foundation of its Museum—of all these the book contains a most trustworthy and interesting record. In every page appears the genuine love of the author for his country—for its scenery, its people, its traditions—and his earnest zeal for its honour and its welfare. He pleads for the preservation of our ancient monuments, for the publication of the manuscript materials of Irish History and Philology, and protests against the mistaken policy of effacing the vestiges and affections of Irish Nationality, instead of consecrating the one and developing the other as a grand portion of the common treasure of the Empire.

In 1874 Dr. Stokes was elected President of this Academy. The position was one to which he was not only entitled by his eminent services to science, but for which he was specially fitted by the breadth of views and the respect for every form of useful intellectual effort which so remarkably characterised him. None of the distinguished men who have filled our Chair had a more earnest zeal for the honour and the welfare of the Academy. Those of its officers who in a time of peril and difficulty were in constant communication with him can bear testimony to the profound interest—often amounting to painful anxiety—with which he followed everything which seemed likely to affect its fortunes, and to the sound judgment with which he early perceived what might safely be accepted, and what ought never to be conceded.

The general recognition of Dr. Stokes' eminent merits was evidenced by the many titles of honour and other distinctions which he received from learned bodies at home and abroad. The University of Dublin conferred on him the Degree of M. D. *honoris causa*. He was also Honorary LL. D. of the Universities of Cambridge and Edinburgh, and Honorary D. C. L. of the University of Oxford. He was three times President of the King and Queen's College of Physicians, and was appointed by Her Majesty the Queen as her Physician in Ordinary in Ireland. He was Honorary Member of the Imperial Academy of Medicine of Vienna; of the Royal Medical Societies of Berlin, Leipsic, and Ghent; and of several other similar scientific bodies in Europe and America. Finally, he was named in 1875 one of the Members of the highly distinguished German Order, Pour le Mérite. During his life was erected by a number of his professional and other friends and

admirers the excellent portrait statue of him from the chisel of Foley, which stands in the Hall of the College of Physicians, and which will present to future generations a most truthful and characteristic image of the man as he yet lives in all our memories.

Of Dr. Stokes, as he appeared in private life, this is scarcely the fitting place to speak. But those who were admitted to his intimacy can never lose the impression made by personal contact with his fine intellect and his genial nature. He was eminently a many-sided man: sensible to the charm of poetry, of painting, of music, delighting in the play of humour, responsive to every touch of tender feeling; with strong convictions, yet of a thoroughly tolerant temper; sincerely pious, without bigotry or ostentation; free from intellectual narrowness, and without the least tincture of jealousy, welcoming and honouring merit wherever it appeared. The warmth of his affections was attested by many life-long friendships, and his kindness to the poor and suffering is remembered with gratitude in many an humble home.

His life was a useful and a noble one, guided by lofty motives, and directed to worthy ends. A true patriot, he pursued, with disinterested zeal, the objects he thought most important for the interests and honour of Ireland; and his country will long cherish his memory with affectionate pride.

Fleetwood Churchill was an Englishman by birth, but, soon after having taken his Degree of M. D. at Edinburgh, settled in Dublin, and from the first devoted himself to the obstetric branch of medicine, in which he enjoyed a very extensive practice, and achieved a high reputation. His writings on the Diseases of Women, on Midwifery, and on the Diseases of Children, are works of great merit, and were long the established text-books on these subjects. In 1848 the University of Dublin conferred on him the Honorary Degree of M. D., and about the same time he was elected an Honorary Fellow of the King and Queen's College of Physicians. In 1856 he became King's Professor of Midwifery in the School of Physic. During the years 1867–8 he filled the office of President of the College of Physicians. When retiring from practice in 1875, he presented to that College his large and valuable collection of ancient and modern obstetrical works; and the College directed his portrait, an excellent likeness, by Thomas

A. Jones, President of the Royal Hibernian Academy, to be placed in its great Hall.] Dr. Churchill was a man of sterling integrity and of great kindliness of nature, and was respected and esteemed both by the public and by his professional brethren.

Mr. Conwell was an intelligent and industrious student of our National Antiquities. Several Papers of his appear in our Proceedings: amongst others, those on the Identity of the Ancient Cemetery at Loughcrew, in the County of Meath; on hitherto undescribed Antiquarian Remains at Sliebh-na-Cailligh, in the same county; on Sepulchral Cairns on the Loughcrew Hills; and on the Lia Fail at Tara.

Mr. Denis H. Kelly served for several years on the Council of the Academy, and his gentle and kindly manners must have left agreeable recollections in the minds of many of our Members. He took much interest in Irish Manuscript literature, and in our ancient architectural and other National memorials. He contributed to our Proceedings Papers on the Strokestown Crannog; on a Terraced Hill near Castleblakeney; on Inscribed Stones at Fuerty, in the County of Roscommon; on two Manuscripts of Duald Mac Firbis; and on the Time and Topography of the Bruighean da Choga. He compiled and presented to our Library an Alphabetical Index to Mr. O'Curry's Catalogue of the Academy's Irish Manuscripts. He also presented to the Academy the Ferguson Manuscripts, being a series of Extracts from the Memoranda Rolls of the Exchequer and other record authorities.

Mr. Henry Wilson, who was so highly and so justly esteemed, and whose early death was so deeply regretted by his medical brethren and the public, gave much attention to the study of Irish Antiquities. He contributed to our Proceedings a Description of an Ancient Bronze Shield, which is now in the Museum of the Academy.

APPENDIX TO REPORT.

[1]

"ROYAL DUBLIN SOCIETY,

"KILDARE-STREET,

"6*th April*, 1877.

"MY DEAR SECRETARY,

"The Council of the Royal Dublin Society have directed me to request you to move the Council of the Royal Irish Academy to sanction a conference between the President and Science Committee of the Academy and a Committee of the Society, composed of the following Members, viz. :—

SIR RICHARD GRIFFITH, BART., F. R. SS. L. & E., *Vice-President, R. D. S.*
THE VERY REV. THE PROVOST, T. C. D., F. R. SS. L. & E., *Vice-President, R. D. S.*
THE EARL OF ROSSE, F. R. S.
REV. MAXWELL CLOSE, M. A.
PROFESSOR BARRETT, F. R. S. E.
PROFESSOR HULL, M. A., F. R. S.
PROFESSOR MACALISTER, M. D.
HOWARD GRUBB, M. E., F. R. A. S.
CHARLES A. CAMERON, M. D., F. R. C. S. I.
ROBERT M'DONNELL, M. D., F. R. C. S. I.
GEORGE JOHNSTONE STONEY, M. A., F. R. S., *Secretary, R. D. S.*

"The object of the conference would be to ascertain whether conjoint action can be recommended to the two Societies in reference to the following suggestions, which have been made by a Committee of the Royal Dublin Society, viz. :—

"'1st. It is most desirable that a Society devoted *exclusively* to Science should exist in Dublin.'

"'2nd. We deem it essential that the Scientific Society shall have such resources as will make it independent; that is, such a capital sum as, along with its annual income from subscriptions, will enable it to

defray all such expenses as those that are borne by the private funds of the similar learned Societies assembled in London at Burlington House.'

"I am to request you to lay before the Council of the Royal Irish Academy the inclosed copy of a Memorandum of Agreement between the Royal Dublin Society and the Government, some of the provisions of which are important to be taken into account.

"I am,
"My dear Secretary,
"Yours faithfully,
"G. Johnstone Stoney,
"*Secretary, Royal Dublin Society.*

"The Secretary of the Council,
"*Royal Irish Academy.*"

Memorandum

Of Provisions, supplementary to those contained in Lord Sandon's Letter of the 8*th February*, 1876, *agreed to at Meeting of the* 5*th March*, 1877.

Present: Sir M. Hicks Beach, M. P.; Viscount Sandon, M. P.; Mr. W. H. Smith, M. P.; Mr. John F. Waller, LL. D.; Colonel Charles C. Vesey; Mr. Samuel F. Adair; Mr. G. Johnstone Stoney, F. R. S., Secretary R. D. Society.

1. The Government will allot to the Royal Dublin Society in Leinster House such accommodation, free of rent and taxes, as in the judgment of the Government is sufficient for the functions of the Society still remaining to it in Science and Agriculture. The conditions of occupation will be the same as those accorded to the learned Societies in Burlington House.

2. The Government will propose a Grant of £10,000, to be invested by the Society, with the approval of the Government, and to be made subject to the Trusts of the present Charters, or any alterations of them, in full compensation for any proprietary right of the Society in the lands, buildings or collections, with the exception of the Scientific Serials, the Transactions, &c., of other learned Societies, and the Works of Art at present in Leinster House, of which last a

st shall be made, to be approved by the Government. Provision to made for full and free access by the public at all reasonable times the Serials and Transactions referred to.

3. The opinion of the Librarian of the British Museum shall be ken as to any earlier editions of modern books, or duplicates, which his judgment are not required for the National Library: and such ooks shall be re-transferred to the Royal Dublin Society.

4. The Society in future to provide its own staff of officers and its own printing. But the Government will authorize the Stationery Office to continue to print the Proceedings and Transactions of the Society—limiting them strictly to its Scientific work—for a period of five years from the date of the transfer of the collections, with the view of assisting the Society to re-organize itself on an independent basis.

5. The Lecture Hall, Laboratory, and the necessary offices to be reserved to the Society, or an equivalent provided.

6. The existing privileges of passing through Leinster Lawn and the Court Yard of Leinster House to be reserved to Members of the Society.

7. Subject to the consent of the Director, the collections in the Botanical Gardens and the Natural History Museum to be available, as heretofore, in illustration of the papers read before the Society.

8. Members who have joined the Society before the 1st of January, 1878, to be allowed to borrow books as at present from the Library, subject to regulations to be laid down by the Librarian, and to have free admittance to the Museum at all times at which it is open to the public.

9. The Government will either allow the Agricultural Shows of the Society to be continued in Kildare-street, affording equal facilities to those enjoyed at present, or provide, either by Grant or by lands and buildings, for a transfer of the Shows to some other convenient place. The Government will inform the Society, as soon as possible, whether the Shows will be left where they are, or removed.

10. If such transfer is effected, account shall be taken of any loss the Society may be subjected to by reason of the removal of the Shows from the centre of the City to the Suburbs, or by discontinuance of the aid given in the maintenance of the buildings, and the Government will ask for Votes accordingly.

14. The Royal Dublin Society will undertake
passage of the Bill now before Parliament, and w
introduction of any clause or clauses that may be
the Library and the Collections in Her Majesty's Go
purpose of a Public Library and Museum.

15. The Government will be prepared, at the
Society, to recommend to Her Majesty to grant such
charters as, in the opinion of the Government, may be
altered circumstances and condition of the Society.

Signed on behalf of the above-named,

WILLIAM H. SMITH, *Secretary to the Treasur*

G. JOHNSTONE STONEY, *Secretary to the Royal*

5th March, 1877.

[Mr. C. Uniacke Townshend, the other member of the depu
this Memorandum, but was unable to attend the meeting of
which it was signed.]

[2]

"10*th o*

"MY DEAR SIR,

"Your letter of the 6th inst. was considered by th
Royal Irish Academy at its last Meeting, and the follo
was adopted, which I am directed to communicate t
formation of the Council of the Royal Dublin Society

gentlemen, and consider the views and suggestions they may put forward, and report the same to the Council of the Academy, with such observations as they may deem expedient; but not to take part in any joint expression of opinion.'

"I am instructed to add that the Council of the Academy does not wish to be understood as entertaining with favour any proposal which would contemplate a restriction of the sphere of the Academy's operations, or would involve a radical change in its constitution.

"I am, my dear Sir,

"Yours faithfully,

"John K. Ingram,

"*Secretary of Council, R. I. A.*

"George Johnstone Stoney, Esq., F. R. S.,

"*Secretary, Royal Dublin Society.*"

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[3]

"Royal Dublin Society,

"Kildare-Street,

"19*th April*, 1877.

"My dear Sir,

"I beg to acknowledge the receipt of your letter of the 10th inst., containing a copy of a Resolution passed by the Council of the Royal Irish Academy in reference to the invitation of the Council of the Royal Dublin Society, contained in my letter of the 6th inst., requesting the Council of the Academy to sanction a conference of Committees of the two Societies, for the purpose of ascertaining whether conjoint action can be recommended to both Societies in reference to the two propositions contained in my letter.

"The Resolution of the Council of the Royal Irish Academy in effect empowers the President and Science Committee of the Academy to receive the Members of the Royal Dublin Society named in my letter, only as a Deputation.

"As this Resolution appears to have been based upon a misconception of the nature of the invitation which the Council of the Royal Dublin Society had instructed me to make, I am directed to explain that the object of the invitation was to elicit the opinion of a body of scientific men representing the Academy and the Royal Dublin Society,

desired to express the hope that the Council of tl
allow their Science Committee to meet the Committ
in conference, to discuss and advise, and not merely t
a Deputation; inasmuch as a conference of the kin
Council of this Society is alone likely to lead to any

"I am, my dear Sir,

"Yours faithfully,

"G. JOHN

"*Hon*

"J. K. INGRAM, ESQ., LL. D.,
"*Secretary of Council, R. I. A.*"

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[4]

"*30th*

"MY DEAR SIR,

"I have received your letter of the 19th instant, before the Council of the Royal Irish Academy.

"In my reply to your letter of the 6th instant, I the willingness of the Council that a conference shou tween the Science Committee of the Academy an nominated by the Council of the Royal Dublin Socie gentlemen might have an opportunity of stating an views, and having them considered by the Committ Committee, after such consideration, might make suc

"A conclusion might possibly be affirmed by a majority of the members of the conference, and a consequent expression of opinion come to the Council, which would be at variance with the views of the Science Committee of the Academy. This would be practically to supersede on the occasion the Science Committee in the office which belongs to it exclusively, of advising the Council on all matters relating to the cultivation or interests of Science.

"I am therefore directed to inform you that the Council, whilst prepared to sanction the holding of the conference on the basis of the Resolution already communicated to you, cannot agree to such a course as is suggested in your letter of the 19th instant.

"I am, my dear Sir,

"Yours faithfully,

"JOHN K. INGRAM,

"*Secretary of Council, R. I. A.*

"GEORGE JOHNSTONE STONEY, ESQ., F. R. S.,

"*Secretary, Royal Dublin Society.*"

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[5]

"ROYAL DUBLIN SOCIETY,

"KILDARE-STREET,

"*10th of May* 1877.

"MY DEAR SIR,

"I have laid before the Council of this Society your letter of the 30th ult., in which you inform me that the Council of the Royal Irish Academy, whilst prepared to sanction the holding of a conference on the basis of the Resolution already communicated to me, cannot agree to such a course as is described in my letter of the 19th ult., and, in reply, the Council of this Society direct me to express, through you, to the Council of the Royal Irish Academy their regret that the Council of the Academy have not allowed such a conference to take place as was proposed by the Council of this Society.

"Such a conference would have brought together a body of scientific men, sitting apart from Agriculturists and Antiquarians, and not representing exclusively the Corporation of the Academy or the Corporation of the Royal Dublin Society. There was therefore reason to

hope that it would have been possible, through this conference, to tain the advice of a body of scientific men upon the real questi issue, viz., What course will be best for the future of Science in land, under the special opportunities which have arisen?

"It would, in the opinion of the Council of the Royal Du Society, have been for the advantage of Science, and for the pu advantage, that this issue could have been placed before such a ference without the complications that arise from antiquarian agricultural pursuits, and from the supposed interests of partic Corporations.

"The Council of the Royal Dublin Society wish it to be distin understood that, in entering upon this negociation, they have b actuated by the desire to leave no means untried whereby the scie fic branches of the two Societies might in future act together. It therefore very much to be regretted that the Council of the Acade have declined the invitation.

"I am, my dear Sir,

"Yours faithfully,

"G. Johnstone Stoney,

"*Hon. Secretary.*

"John K. Ingram, Esq., LL. D.,

"*Secretary of Council, R. I. A.*"

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[6]

"*23rd of May*, 1877.

"My dear Sir,

"I beg to acknowledge the receipt of your letter of the 10th ins and in reference thereto I am directed by the Council of the Roy Irish Academy to remind you that they have not declined the holdi of the conference proposed by the Council of the Royal Dublin Societ but have agreed to it, on the only basis on which it seemed to them could be properly held. This they did through respect for the Coun of the Royal Dublin Society, and because they thought the conferenc rightly conducted, might have led to useful results. It must, how ever, be understood that in their opinion the Council of the Roy Dublin Society, in devising measures for the promotion of gener Science, is occupying itself with a subject with which, under th

Charter of the Society, it is not authorised to deal. It was established for the promotion of Husbandry and the useful Arts, and has never obtained authority to undertake the cultivation of abstract Science.

"The Council, however, have observed with regret that some Members of the Society are seeking to divert it from its proper functions which it has discharged with honour to itself and advantage to Ireland, and to embark it in the new career of the promotion of abstract Science, The effect of this course of proceeding, which is quite unwarranted by its existing Charters, is to engage it in a permanent competition with the Royal Irish Academy, by which Science, in the largest sense, has (in accordance with its Charter) been cultivated; and this competition will, it is believed, be injurious to both Bodies, as well as to the country at large, which will lose the services in relation to industrial subjects hitherto rendered by the Royal Dublin Society.

"The Council have therefore felt it their duty to make a representation on the subject to Her Majesty's Government, a copy of which I have been instructed to send you, for the information of the Council of the Royal Dublin Society, as soon as I shall be in possession of an acknowledgment of its receipt by the Government Department to which it has been addressed.

"I am, my dear Sir,

"Very faithfully yours,

"JOHN K. INGRAM,

"*Secretary of Council.*

"GEORGE JOHNSTONE STONEY, ESQ., F. R. S.,

"*Secretary, Royal Dublin Society.*"

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[7]

"ROYAL IRISH ACADEMY HOUSE,

"DUBLIN, 22*nd of May*, 1877.

"GENTLEMEN,

"I am directed by the Council of the Royal Irish Academy to ask your attention to one of the heads of agreement between the Government and the Royal Dublin Society, embodied in the Memorandum of Provisions agreed to on the 5th of March last.

"The Royal Dublin Society was established by Charter in 1750,

under the name of the 'Dublin Society for promoting Husbandry and other useful Arts in Ireland.'

"A supplemental Charter was granted in 1866. Nothing is enacted in it respecting a change of the objects of the Society, which is described as the Dublin Society for the Promotion of Husbandry and other useful Arts and Sciences in Ireland. The intention was plainly not to alter the sphere of labour which it had always honourably fulfilled, namely, that of advancing the Agricultural and Industrial interests of the country; and the phrase 'useful Arts and Sciences' shows that it was meant still, as before, to occupy itself, not with abstract Science (which had been provided for in the Royal Irish Academy), but only with Science in relation to its industrial or economic applications. The fact of some Papers not answering to this description having been read at its Meetings in recent years cannot affect the true character of the Society, or the correct interpretation of its Charters and its history. At present, however, as we have reason to know, some of its most active Members entertain the project of diverting it from the objects which it was founded to promote, and embarking it in the cultivation of abstract Science. To enable it to alter its character in this way, a new Charter would be necessary.

If such a Charter should be sought, it will become the duty of the Royal Irish Academy, which was established by Royal Charter for the cultivation of Science, in the largest acceptation of the word (as well as of other studies), and has fully and faithfully discharged its duty in that field, to represent to the Government the impolicy of public resources being used for the establishment in a city like Dublin of a second Society, which would occupy the same intellectual domain, and thus carry on an active competition, with the Royal Irish Academy; whilst, on the other hand, Ireland would be deprived of the valuable services, in relation to industrial subjects, which are performed for England by the Society of Arts, and have hitherto been rendered to this country by the Royal Dublin Society.

"But the point to which the Council desire at present to ask the attention of the Government is a less general one, which, however, requires more immediate notice.

"In Article 4 of the terms of agreement lately entered into between the Government and the Royal Dublin Society, it is stated that the Government will authorise the Stationery Office to continue

to print the *Proceedings* and *Transactions* of the Society, limiting them strictly to its scientific work, for a period of five years from the date of the transfer of the collections referred to in preceding Articles. We believe that the intention of the Government, in using the words 'limiting them strictly to its scientific work,' was not to sanction indirectly an enlargement of the sphere of the Society's operations, or the diversion of them into a new channel, but to exclude such publications as might relate to the practical action of the Society in connexion with Agriculture. And if the words be so interpreted, we are far from objecting to the privilege thus accorded to the Royal Dublin Society. On the contrary, we regard it as dictated by the kindest feelings, and as a seasonable and thoughtful aid to the Society, whilst reorganising itself on an independent basis. But we have reason to believe that the intention is entertained by some Members of the Society to take advantage of the word 'scientific,' used in this Article, as if it authorised the printing of matter belonging to abstract, as distinguished from practical Science, and to the exclusion of Industry and Art. This, we beg to represent, cannot be done under the existing Charter of the Society, and we must respectfully express our opinion that it would be a misapplication of public funds to use them for that purpose.

"The Council, therefore, humbly submit that the word 'scientific' in Article 4 must be construed as relating, not to abstract Science, but to the practical application of Science in the useful Arts, and that no Papers of the former class, which may be proposed for publication by the Royal Dublin Society, should be printed at the public expense, so long, at least, as that Society is governed by its present Charter. And if it should be proposed to grant a new Charter, with such extended powers as have been above referred to, the Council respectfully claim to be allowed to submit to Her Majesty's Government their reasons for objecting to the adoption of such a course.

"I am, Gentlemen,

"Your obedient Servant,

"(Signed) John K. Ingram, LL. D.,

"*Secretary of the Council.*

"To the Lords Commissioners of Her Majesty's Treasury,

"*Whitehall.*"

"I am,

"My dear Sir,

"Yours faithful

"JOHN K

"*Secretary of C*

"GEORGE JOHNSTONE STONEY, Esq., F. R. S.,
"*Secretary, Royal Dublin Society.*"

The Report was adopted.

The list of recommendations of Scientific Grants w
posed by the Secretary for adoption by the Academy :-

£25 to C. R. C. Tichborne, F. C. S., for Researches
ral diffusion of Fluorine in Animal Concretions, &c.

£25 to E. T. Hardman, F. C. S., for Apparatus a
enable him to continue his Chemico-Geological Resear

£20 to A. G. More, F. L. S., for the Examination
the South and West of Ireland.

£12 to A. Leith Adams, M. D., F. R. S., towards
collecting materials relating to the Natural History of
with the view of producing a Monograph on the subje

£18 to Rev. J. H. Jellett, B. D., for Researches
between Light and Electricity.

The Grants to Mr. Tichborne, Mr. Hardman, Mr. More, Dr. Leith ams, Rev. J. H. Jellett, and Dr. Macalister, were adopted without ivision; but the recommendation of £70 to Professor Oswald Heer s negatived on a division.

It was proposed by Dr. Lyons, and seconded by Dr. M'Sweeny—

"That it be referred back to the Council to reconsider the alloca- n of the sum of £70, not yet granted, in connexion with the Tertiary ra of Ireland; and that the Council is hereby empowered to allot Grant specified in the manner that shall now seem best to them."

The following amendment was proposed by the Secretary of Coun- :—

"That the words relating to 'the Tertiary Flora of Antrim' be itted."

The amendment having been negatived, the original motion was ied.

The Scrutineers having duly reported, the President declared the owing duly elected as President and Council for the ensuing Ses- :—

PRESIDENT.

SIR ROBERT KANE, LL. D., F. R. S.

COUNCIL.

Committee of Science.

Edward Perceval Wright, M. D., F. L. S.; David Moore, Ph. D., L. S.; John Casey, LL. D., F. R. S.; Thomas Hayden, M. D.; r. J. H. Jellett, B. D., S. F. T. C. D.; Alexander Carte, M. D., L. S.; William Archer, F. R. S.; Rev. Samuel Haughton, M.D., R. S.; Bindon B. Stoney, M.A., C.E.; Robert S. Ball, LL. D. R. S.; Edmund Davy, M. D.

Committee of Polite Literature and Antiquities.

John Kells Ingram, LL. D., F. T. C. D.; William J. O'Don- van, LL. D.; Alexander G. Richey, Q. C., LL. D.; John R. Gar- n, LL. B., F. S. A.; Very Rev. W. Reeves, D. D.; Rev. Thaddeus Mahony, D. D.; Robert Atkinson, LL. D.; Lord Talbot de Mala- e, F. R. S.; Samuel Ferguson, Q. C., LL. D.; J. T. Gilbert, F. S. A.

elected :—

TREASURER.—John Ribton Garstin, LL. B.

SECRETARY OF THE ACADEMY.—Robert S. Ball, LL

SECRETARY OF COUNCIL.—Robert Atkinson, LL. D.

SECRETARY OF FOREIGN CORRESPONDENCE.—William

LIBRARIAN.—J. T. Gilbert, F. S. A.

CLERK OF THE ACADEMY.—Edward Clibborn, Esq.

The following gentlemen were declared by the Pr
of the Scrutineers, duly elected Honorary Members :

In the Department of Science.

Louis Pasteur, Paris.
Sir William Thomson, Glasgow.

In the Department of Polite Literature and A

Dr. George Curtius, Leipsic.
Henry Bradshaw, Cambridge.
Dr. H. Kern, Leyden.
Charles Newton, London.

The President, under his hand and seal, nominated
Vice-Presidents for the year 1878–79 :—

Samuel Ferguson, LL. D. ; Thomas Hayden, M

MONDAY EVENING, APRIL 8, 1878.

SIR ROBERT KANE, LL. D., F. R. S., President, in the Chair.

By permission of the Academy, Professor Robert Galloway read a per "On the Extraction of Iodine and Bromine from Kelp."

[This Paper will appear in the *Proceedings*, Ser. ii., vol. iii., ence, part 2.]

Dr. E. P. Wright, F. L. S., read a Paper—"Notes on Algæ No. 2; the Development of the Cell Structure and of the Antheridia in iffithsia; On the Development of the Siphons and Tetraspores in lysiphonia

[This Paper will be published in vol. xxvi. of the *Transacns*."]

Donations to the Library were announced, and thanks voted to the iors.

MONDAY EVENING, MAY 13, 1878.

SIR ROBERT KANE, LL. D., F. R. S., in the Chair.

Rev. John O'Reilly, C. C.; George L. Cathcart, Jun., M. A; n Browne, Esq.; Professor Robert Galloway, and John Kane, Esq., re elected Members of the Academy.

E. W. Davy, M. D., read a Paper "On a New Chemical Test for bolic Acid, and its Useful Applications."

[This Paper will appear in the *Proceedings*, Ser. ii., vol. iii., ence, part 2.]

The Right Rev. the Lord Bishop of Limerick read a Paper "On o Ancient Inscribed Monuments."

The Secretary read Papers by J. C. Malet, M. A., "On a Certain face derived from Quadrics," and "On an Elementary Proof that ry Equation has a Root."

[This Paper will be published in vol. xxvi. of the *Transacs*."]

The Secretary read a Paper by Mr. O'Dowling "On Celtic nes in the Tyrol and Carinthia."

Donations to the Library were announced, and thanks voted to the nors.

tions.]

The President delivered the following Address
the delivery of the Cunningham Medals to Dr. A
fessor Casey, Professor Dowden, and Professor Alln

"GENTLEMEN,

"Among the duties which devolve upon your
none more honourable, and certainly none more ag
of acting as the organ of the Council and of the A
ring the Cunningham Gold Medals upon those
who may from time to time be selected on accoun
literary, scientific, or archæological merits to re
honorary reward by which, in this country, intelle
recognised. It is now a period of six years sinc
dency of my excellent predecessor, Rev. Dr. Jellet
the Academy conferred upon Sir William Wilde, w
much regret, the Cunningham Medal, in recogn
merits in preparing *The Illustrated Catalogue* of our
which rendered the treasures of that unequalled col
appreciated by all students of Archæology and Art,
as we have frequent example, to the great credit
the Academy. Since that time the labours of t
the original researches of our Members, have bee
so much success, and in such varied fields, as
tained the character of this Institution among th
Europe, and has afforded to the Council an area of

ration, to award on this occasion four Gold Medals, viz., one to Aquilla Smith, for his inquiries into Irish Numismatics; one to Casey, for his important mathematical discoveries; one to Pro-or Dowden, for his literary writings, especially in the field of ksperian criticism; and one to Dr. G. J. Allman, for his researches the natural history of Hydrozoa. It will be observed that the idemy has now waived the somewhat narrow condition which had ited the works for which this honour could be awarded to those lished in its *Transactions*, or on subjects immediately connected h this country. In selecting for this mark of their approval the rks of Professor Dowden, which have for their subject him who the poet not of one country but of humanity—not of one period of all time—the Council has worthily expanded the range of uence of the Academy, and has brought our intellectual life into dred and fellowship with the intellects of other lands, so that the tance and separation from other centres of intellectual activity, ich had been on so many occasions objected to our country, can no ger be considered to apply.

I should be thought unpardonably presumptuous, did I attempt to scribe with any detail the grounds upon which the Council founded eir decision as to these Medals, or were I to comment with any ectation of authority on the works of the distinguished persons who to receive them. I shall venture, only in a general way, and very iefly, to indicate the nature of the researches which in each case ve been specially designated by the Council as deserving to be owned with the approval of the Academy.

The study of Numismatics has been paralleled by an eminent ologist with that of Palæontology, as representing, in regard to tory, a series of facts recorded in the concrete material of coins d medals, fixing the order of succession of dates and events, as fossil nains characterise the succession and relative dates of geological mations, but leaving the philosophical interpretation of the cosmi- or political changes by which those facts were caused to be cussed on other grounds and with further sources of information. e study of coins has thus afforded to history and to political ence, as the study of fossils has afforded to geological science, portant means of definition and control; and Dr. Smith, by the uable series of Papers which he contributed to our *Proceedings* and

for the impostor Lambert Simmel that instinctive d
Irish people for the royal title, independent of persona
stitutional principle, which has been so frequently dis
Papers, which at once established Dr. Smith's charac
and accomplished Numismatist, were followed up by
Anglo-Saxon coins, and on the Scottish coins and to
Ireland, others again on the Irish coins of Mary, and
of necessity coined in Ireland of debased materials, as br
in the calamitous periods of the first Charles and of the
Another subject of Dr. Smith's researches was that of
the great Anglo-Norman nobles, whether of the de L
exercising the rights of feudal sovereignty, or as the Fitz
Ormondes, acting by authority of and as representatives
He also directed his attention to the subject of the trad
coined of silver and copper in Ireland, and has the
materials for illustrating many points in the industrial
country. All these careful and laborious inquiries affo
to the historian; but we owe to the zeal and patriotism
far more than even such literary contributions. Th
Irish coins formed by Dr. Smith during his inquiries,
had been sought to obtain for the Museums of the siste
become, owing to his national spirit and liberality, the p
Academy, and being augmented by the collections of
and of Dean Butler, which were similarly acquire
Numismatic treasures of this Academy such as any M
country may be justly proud of.

It will be within the knowledge of many of our Members, that of late years mathematicians have been much occupied with the investigation and development of a new Algebra, transcending in its power of generalization the methods of analysis previously known. This new Calculus may be said to have originated with my late distinguished and lamented colleague Dr. Boole. Subsequently, it has been developed by the labours of Sylvester and of Cayley in England, by the writings of Rev. Dr. Salmon in this country, and by several eminent foreign mathematicians. Among the most important investigations by which this new branch of Science has been enriched in its geometrical relations are those recently published by our colleague Dr. Casey. To those investigations so much value is attached by competent mathematical authorities, that the Council of this Academy did not hesitate to award to Dr. Casey, in recognition of their merit, a Cunningham Gold Medal. I shall attempt, though very briefly, and I fear imperfectly, to notice the general nature of those Papers.

Among Dr. Casey's earlier contributions to this higher modern geometry, is a memoir which was published in volume ix. of the *Proceedings* of this Academy. This Paper contains a number of new and remarkable theorems, with respect to the Contact of Circles and Spheres, as well as some extensions to Conic Sections. But in a historic notice of Dr. Casey's labours, this Paper is of especial interest, inasmuch as it contains the germ of those new analytical methods which he has developed with such extraordinary success in his subsequent works. The principal features of these methods are well illustrated in the great Paper on "Bicircular Quartics" which he laid before this Academy in February, 1867, and which appears in volume xxiv. of our *Transactions*.

The curves known as bicircular quartics are a peculiar class, included under the more general designation of curves of the fourth degree. The properties of these curves had been already, to some extent, investigated before the commencement of Dr. Casey's labours, but it was found that the ordinary Cartesian analysis is not sufficiently tractable to be applied to this particular class of curves with advantage; and consequently, before Dr. Casey's work appeared, the true geometrical relations of these curves had been but imperfectly apprehended. By a most elegant analytical conception, Dr. Casey placed the true theory of these curves at once in a proper light. In his new system of co-ordinates, the variables denote circles instead of the straight lines

focal properties which are of so much importance i
description.

The powerful instruments of research thus creat
have been applied by him to the study of the propertie
and he has not only discovered a large number of ne
he had so co-ordinated and arranged the whole theory
the bicircular quartics into an important branch of m

The conspicuous success of this analytical method
naturally suggested to Dr. Casey the study of the corre
in space, of three dimensions. Little was indeed kn
portant class of surfaces called Cyclides, until Dr. C
new analysis to bear upon them. As one of the most
sequences of this application, he discovered that a Cyc
lope of a variable sphere, whose centre moves in a giv
which cuts a given fixed sphere orthogonally. The co
ment of the theory of the Cyclide was published in *T*
Transactions for 1871.

In his next great memoir, "On a New Form of T
tion" (*Phil. Trans.*, 1877), Professor Casey has turned
a somewhat different department of mathematical res
ordinate of a variable line may be defined by the angle
with a fixed line, and by the length of the intercept m
fixed point on the fixed line. An equation between th
is termed by Dr. Casey the tangential equation of the
line. This form of equation lends itself with surprising
geometrical investigations, of which abundant exampl

maticians show that the high reputation which Dr. Casey holds as a mathematician in this Academy is sustained by the opinion in which he is held by mathematicians all over the world. Under such circumstances, I feel sure the Academy will cordially agree with the Council in conferring upon Dr. Casey the Gold Medal which I now feel honoured in presenting to him.

In order to bring under the notice of the Academy the grounds upon which the Council have awarded a Cunningham Gold Medal to Professor Dowden for his literary works, especially in the field of Shaksperian criticism, it is necessary that I should briefly indicate the point of view from which the labours of that gentleman in the field of æsthetic scholarship and psychological analysis may most consistently be considered, with reference to his studies of the life and writings of the Great English Dramatist.

There are two different ways in which the works of some great writers admit of being studied; we may, according to the ordinary usage of critics, consider their productions separately, examining their characteristic features, appreciating their æsthetic excellence and dwelling on their moral significance; or again, in the cases of those who have left us sufficiently numerous and varied products of their genius, we may consider the further question, often still more deeply interesting, according to what laws of progression did the genius of the author develope itself, and the firmness and sureness of his execution increase; how did his views of life gradually form themselves, and arrive at greater width and clearness; how were his moral convictions shaped and fixed; what was the final attitude of his thought and sentiment—in a word, we may seek through his work in some measure to reach himself, to read in some degree the history of his mind.

To arrive at even an approximate answer to these questions, in the case of a nature so rich and so many-sided as that of Shakspere, would evidently be an achievement of no ordinary interest and importance.

Now, before any considerable progress could be made in such a research, a previous condition must be satisfied. It was necessary that a chronological arrangement of the poet's work, sufficiently complete, and established on satisfactory bases, should be in our possession.

The knowledge on this subject was long very imperfec current opinions about it largely conjectural; but since t our countryman Edmund Malone, who first undertook thi scholars have accumulated a mass of evidence, founded part temporary documents which have been brought to light, references in the plays themselves, as to their respective d in recent years, a study of what are called verse-tests, found regularly changing characters of the poet's versification t his career, has been prosecuted with much assiduity, and wi measure of success. The results obtained by this last meth entire harmony with the external evidence, and enable us ment its deficiencies; and thus a chronological scheme has structed, which all competent judges have agreed in accept its essential features, placed beyond reasonable question.

Now, first, by the aid of these discoveries, for such the to be called, our judgment of the poet's works, from the side, becomes more rational. The products of his different p considered apart, and are estimated according to a relative, solute standard. The slight sketches of his almost boyish not placed alongside the highest efforts of his maturity; and being tempted, with some of his worshippers, to maintain the of an equally high standard of excellence in all the poet's are enabled, without compromising our reverence for hi genius, to admit the inferiority of his early productions, nise in the history of his, as of every other mind, the p growth and development.

But further, as is indicated above, when the path has prepared, we can approach with some prospect of success th problem, behind and through the works to find the man, stand what no external record tells us, not merely what h painted, but what he was; in what succession his great p folded themselves, how his conceptions of men and things with his larger experience: what were his ripest and ulti victions respecting human nature and human duty, and general, the final outcome of his spiritual life.

It is chiefly for the valuable contributions of Professor I this inquiry, that the Council has conferred on him the hon I am sure the Academy will gladly ratify. He was in a

degree fitted for the conduct of such a research, by combining in himself several qualifications but seldom united. To the clear insight of the critic he adds the sympathetic enthusiasm of the poet; and with Shakesperian learning, with all that has been written on Shakesperian subjects, whether at home or abroad, he is, perhaps, more conversant than any other living scholar. He has thus been enabled to furnish what the voice of the best judges pronounces to be the best extant solution of the profoundly interesting question to which I have referred, and to produce a work which has not merely achieved a great present success, but will long continue, as I believe, to be the cherished companion and guide of the Shakesperian student.

These general remarks will have sufficiently indicated the spirit in which Professor Dowden has discussed the æsthetic and psychological characteristics of the personages of the Shaksperian drama. It would be impossible for me to notice in detail his treatment of those subjects, but I may venture to point out his masterly comparison of the mental peculiarities of Romeo, of Hamlet, and of Brutus. Those grandly elaborated types of tragic passion, each of whom by the overmastery in the one of sensuous emotion, in the second of abstract meditation, and in the third of stoic idealism pervading their mental nature, had lost the faculty of dealing suitably with the requirements of practical life, and, having become the mere instruments in events which they had lost all power to control, were led on to those tragical issues of which we have all read with interest and sympathy. His critical appreciation of the variety in Shakspere's treatment of the supernatural as an element of dramatic composition appears to me also peculiarly just and elegant, where he contrasts the earlier period when genial and playful Puck, Oberon, and Titania, carry on the amusing mystifications of the "Midsummer Night's Dream," with the later period where the horrid witchery of Demoniac chants lures Macbeth to his fate by double meanings; and, finally, where with the kindly grace of Ariel, and the wisdom of Prospero supernaturally matured, such powers are shown to be employed only as ministers of justice and of mercy, to be surrendered, once that the good object of their exercise has been accomplished.

The President here presented the Gold Medal to Professor Edward Dowden.

Although for some years back Dr. Allman has transferred his personal activity to the wider field of the sister kingdom, yet he has never ceased to be heartily and thoroughly identified with this Academy, and with this country. It will, therefore, not require many words to explain to the Academy the grounds on which the Council decided to confer on him a Cunningham Gold Medal.

The varied and beautiful forms of life which under the names of Zoophytes, of Polypes, or of Anthozoa, the corals and sea flowers, have excited so much popular interest and have been objects of so much instructive inquiry, were, even after the recognition of their animal nature, considered until lately to belong exclusively to the lowest stage of animal existence, the Radiata of Cuvier; and their structure was supposed to be only the elementary form of a digestive sac, whose aperture was surrounded by retractile arms, to which nutriment was conveyed by vibrating cilia, expanded over the solid base or polypedome to which the associated organisms belonged. It was, however, discovered that, among the bodies usually known as Polypes, great diversity of habits and of structure could be observed. Among the first to recognise this diversity, and to point out that certain forms of Polypes were of much higher organization than others, and should occupy a much higher place in zoological classification than had been previously supposed, was our fellow-countryman, Mr. J. V. Thompson, already distinguished by his remarkable discovery of the larval metamorphoses of certain of the Crustacea, but unhappily since so prematurely lost to Science. His observations, verified and followed up by various foreign naturalists, were extended and completed by Professor Allman with admirable skill and perseverance, great originality of thought, and closeness of reasoning, in the remarkable series of memoirs by which the history of these animals has been entirely remodelled, and placed on its really scientific basis, their extraordinary phases of reproduction made known, and their true position in the scale of organic existence demonstrated.

I have said that the result of the researches of Dr. Allman and of his fellow-labourers in the same field, of whose merits he has on all occasions in his writings shown himself most scrupulously and delicately appreciative, has been to prove that certain classes of the so-called Polypes belong to certain types of organization much higher than the radiate, approaching even to the lower divisions of the

highest invertebrate type, that of the Mollusca; assimilating themselves most closely to the forms of the compound Tunicated Ascidians, in some of which many of the most eminent naturalists of the present day are disposed to trace the primordial rudimentary source of the vertebrata, the very highest type of animal organization.

This important discovery was announced in the remarkable Paper read by Dr. Allman to this Academy in 1852, and published in volume xxii. of our *Transactions*. Since that time he has continued, by Papers in the Scientific Journals, by Reports to the British Association, and by the admirable monographs published by the Ray Society, to illustrate and advance our knowledge of the structure, the morphology, and the physiology of these tribes of organisms. In doing so, he was obliged to create a new nomenclature, which has now been universally approved and adopted into biological literature. These classes of animals are therefore entirely removed from the true radiate Polypes. They are now known to Science as Hydrozoa and Hydroids, and their position is fixed by certain relations with the Ascidian Molluscs, to which, as I have said, they show close affinity.

Nor is the interest of Dr. Allman's researches limited to the living forms of animal life. I am informed by eminent geological authority that he has also thrown new light upon some of the most obscure questions of palæontology, and that the Graptolites of the Silurian system, almost the oldest and most mysterious forms of palæozoic existence, are now known by Dr. Allman's investigations to have been Hydrozoa.

The extraordinary series of transformations exhibited by many of these animals, in virtue of a process of alternate generation by ovules and by buds, has been specially illustrated by Dr. Allman in his "Monograph on the Hydroida" published by the Ray Society. That the medusæ, the sea nettles, which swim about our coast, and which in their countless myriads light up with gleaming phosphorescence the darksome waste of ocean, should be but highly developed buds of polypoid forms, must strike the scientific equally as the popular mind with surprize and admiration. That such wandering forms, endowed with powers of locomotion, with organs of higher sense, with sight and hearing, of course in imperfect and rudimentary condition, can be derived from a fixed polypoid base, that forms, alternately sexual and non-sexual, can rise from a common source—

That he has been elected to the office of President o
Society of London is in itself the verdict of the Bi
United Kingdom, and of Europe. In thus honouring hi
feel that we do honour to ourselves and to our country.

The Academy will concur in my regret that we
pleasure of presenting this Medal to Dr. Allman in p
friend the Rev. Dr. Haughton will take care that the
duly forwarded and delivered to Dr. Allman, by whom
requested to receive it on his part.

A vote of thanks to the President for his Address w
Professor Hennessy, seconded by Professor Haughton, a
by acclamation.

Dr. Smith, Professor Casey, and Professor Dowden
and received their Medals from the President.

Professor Allman not being able to come to Dubl
awarded to him was received on his behalf by Professor

Donations to the Library were announced, and than
Donors.

MONDAY EVENING, JUNE 24, 1878.

SIR ROBERT KANE, LL. D., F. R. S., in the Ch

Joseph A. Beatty, Esq., William J. Corbet, Es
William A. Reynell, B. D., were elected Members of th

The Rev. H. Lloyd, D. C. L., Provost, T. C. D., rea

By permission of the Academy, Mr. E. T. Hardman read a Paper "On an Undescribed Mineral from near Carnmoney Hill, near Belfast."

[This Paper will appear in the *Proceedings*, ser. ii., vol. iii., Science, part 2.]

Professor O'Reilly exhibited and described a Plan of 200 Basaltic Columns, with Angular Measurements.

[This Paper will be published in vol. xxvi. of the *Transactions*.]

By permission of the Academy, Mr. E. Lapper read a Paper "On the Distillation Products of the Saccharates of Ammonium and Ethyl-ammonium."

[This Paper will appear in the *Proceedings*, ser. ii., vol. iii., Science, part 2.]

By permission of the Academy, Dr. Chichester Bell read a Paper "On Further Observations on Pyrrol and its Derivatives."

[This Paper will appear in the *Proceedings*, ser. ii., vol. iii., Science, part 2.]

Donations to the Library were announced, and thanks voted to the Donors.

The Treasurer laid on the table the following Abstract of the Academy's Accounts for the year ending 31st of March, 1878, as audited by William Archer, F. R. S., and William J. O'Donnavan, forming the Committee of Audit.

The Academy was then adjourned to November.

ROYAL

GENERAL ABSTRACT OF THE ACCOUNT OF JOHN

FOR THE YE

RECEIPTS.	For Special Purposes.	For General Purposes.
	£ s. d.	£ s. d.
Balance from last Year,	8 9 6	3 18 5
FROM PARLIAMENTARY GRANTS:—		
Unappropriated:—"Old Grant,"	. . .	500 0 0
Appropriated:—		
Preparation of Scientific Reports,	130 0 0	
Library,	200 0 0	
Researches in connexion with Celtic MSS.,	200 0 0	
Publication of ditto,	200 0 0	
Museum,	200 0 0	
Purchase of Treasure Trove,	100 0 0	
Illustration and Printing of "Transactions" and "Proceedings,"	200 0 0	
Opening the Academy in the evening,	152 7 4	
" TRINITY COLLEGE GRANT towards reproduction of the MS. known as the Book of Leinster (on account of £700) making £500,	80 0 0	. . .
" MEMBERS' PAYMENTS:—		
Entrance Fees,	. . .	47 5 0
Annual Subscriptions,	. . .	373 16 0
Life Membership Composition (*invested as opposite*),	70 7 0	
" PUBLICATIONS SOLD:—		
Transactions,	. . .	26 1 8
Proceedings,	. . .	5 18 10
" Irish MSS. Series,	. . .	1 0 4
Leabhar Breac,	. . .	20 15 0
Leabhar na h-Uidhri,	. . .	8 11 0
Museum Catalogue (*invested as opposite*),	3 10 7	
" INTEREST ON INVESTMENTS:—		
Life Composition—Consol. Stock,	. . .	76 3 10
Cunningham Bequest—New 3 per cent. Stock (*see opposite*),	76 14 3	
Museum Catalogue—Bank of Ireland Stock (*see opposite*),	4 16 8	
" TEA FUND Subscriptions,	6 10 0	
	£1632 15 4	1063 10 1

I certify that the above account is correct, according to the

.DEMY.

TIN, TREASURER OF THE ROYAL IRISH ACADEMY,

? MARCH, 1878.

PAYMENTS.	From Funds appropriated for Special Purposes. £	s.	d.	From Funds available for General Purposes. £	s.	d.	Total of each Cla £	s.
R SCIENTIFIC AND LITERARY PURPOSES:—								
Polite Literature and Antiquity Objects, .	.	.	.	.	.	.		
Scientific Reports, ...	130	0	0					
Library, ...	200	0	0	110	3	2		
Irish Scribe, &c., ...	200	0	0	0	3	5		
" (including Lithographing of Book of Leinster, and Printing Felire of Aengus, ...	200	0	0					
Museum, ...	200	0	0					
Treasure Trove	100	0	0					
Transactions and Proceedings, ...	200	0	0	187	16	7		
Opening the Academy in the evening, . .	152	7	4					
Book of Leinster, ...	83	4	0					
							1763	14
ESTABLISHMENT CHARGES:—								
Salaries, ...	.	.	.	409	0	0		
Wages and Liveries, ...	.	.	.	221	14	6		
Furniture and Repairs, ...	.	.	.	8	9	4		
Fuel, ...	.	.	.	34	3	0		
Insurance, Taxes, and Law, ...	.	.	.	8	2	6		
Stationery, ...	.	.	.	12	16	6		
Printing (Miscellaneous), ...	.	.	.	12	15	6		
Postage, ...	.	.	.	25	4	11		
Freights, Incidentals, and Contingencies, .	.	.	.	18	0	4		
							750	6

INVESTMENTS (CAPITAL):—

	Stock Bought. £	s.	d.	Description.	Total Stock. £	s.	d.	From Funds appropriated for Special Purposes. £	s.	d.	Total of each Cla £	s.
Membership Compositions, .	73	18	3	Consol. Stock,	2645	18	5	70	7	0		
ingham Bequest Interest, lance, . . .	81	8	11	New 3 per Cents,	2699	18	4	76	14	3		
Catalogue,	2	10	11	Bk. of Ir. Stock,	42	16	9	8	7	3		
											155	8

	£	s.	d.	£	s.	d.	£	s.
TEA FUND Expenditure, ...	6	10	0	11	16	1	18	6
	£1627	9	10	1060	6	1	2687	15
Balance to Credit of the Academy,	5	5	6	3	4	0	8	9
	£1632	15	4	1063	10	1	2696	5

ge and belief, JOHN RIBTON GARSTIN, *Treasurer, R. I. A.*

AUDITORS' REPORT.

We have examined the above General Abstract, and compared
the details of the several heads thereof, and find the same to be c
Balance of Eight Pounds Nine Shillings and Six Pence to the cr
demy; which amount is certified by the Accountant-General to h
the credit of the Academy's account in the Bank of Ireland on t
1878.

The Treasurer has also exhibited to us like Certificates i
invested *Capital*, showing that the amounts of Stock standing
the Academy on the same day were £2699 18*s*. 4*d*., New Th
£2645 18*s*. 5*d*., Consols; and £42 16*s*. 9*d*., Bank of Ireland Stoc

(Signed),

WILLIAM ARCHER,
WM. J. O'DONNAVAN,

21*st of May*, 1878.

LIST

OF THE

COUNCIL AND OFFICERS

AND

MEMBERS

OF THE

ROYAL IRISH ACADEMY;

DUBLIN,

1st of May, 1878.

DUBLIN:
ACADEMY HOUSE, 19, DAWSON STREET.
1878.

THE ROYAL IRISH ACADE

A.D. 1878.

Patron:

HER MAJESTY THE QUEEN.

Visitor:

HIS EXCELLENCY THE LORD LIEUTENANT

ROYAL IRISH ACADEMY.

President:

(*First elected*, 16*th of March*, 1877.)

SIR ROBERT KANE, M.D., LL.D., F.R.S., F.K. & Q.C.P.I.

The Council:

(*Elected* 16*th of March*, 1878.)

The Council consists of the Committees of Science and of Polite Literature and Antiquities.

Committee of Science (Eleven Members):

Elected.	
Mar., 1870	EDWARD PERCEVAL WRIGHT, M.D., F.L.S., F.R.C.S.I.
,, 1872	DAVID MOORE, PH.D., F.L.S.
,, 1872	JOHN CASEY, LL.D., F.R.S.
,, 1873	THOMAS HAYDEN, F.K. & Q.C.P.I., F.R.C.S.I.
,, 1874	REV. JOHN HEWITT JELLETT, B.D., S.F.T.C.D.
,, 1875	ALEXANDER CARTE, M.D., F.L.S., F.R.C.S.I.
,, 1875	WILLIAM ARCHER, F.R.S.
,, 1876	ROBERT STAWELL BALL, LL.D., F.R.S. (*Sec.*)
,, 1877	BINDON B. STONEY, M.A., C.E.
,, 1877	REV. SAMUEL HAUGHTON, M.D., D.C.L., F.R.S., F.T.C.D.
,, 1878	EDMUND W. DAVY, M.A., M.D

Committee of Polite Literature and Antiquities (Ten Members):

Mar., 1859	JOHN KELLS INGRAM, LL.D., F.T.C.D.
,, 1867	WILLIAM JOHN O'DONNAVAN, LL.D.
,, 1869	ALEXANDER GEORGE RICHEY, LL.D., Q.C.
Dec., 1869	JOHN RIBTON GARSTIN, M.A. & LL.B., F.S.A. (*Sec.*)
Mar., 1871	VERY REV. WILLIAM REEVES, D.D., LL.D., M.B., Dean of Armagh.
,, 1873	REV. THADDEUS O'MAHONY, D.D.
,, 1875	ROBERT ATKINSON, LL.D.
Nov., 1876	LORD TALBOT DE MALAHIDE, D.C.L., F.R.S., F.S.A.
Mar., 1877	SIR SAMUEL FERGUSON, LL.D., Q.C.
,, 1878	JOHN T. GILBERT, F.S.A., R.H.A.

Officers:

(*Elected annually by the Academy; with date of first*

TREASURER,	JOHN RIBTON LL.B., F.S.A., (18
SECRETARY,	ROBERT STAW F.R.S., (1874).
SECRETARY OF THE COUNCIL,	ROBERT ATKIN
SECRETARY OF FOREIGN CORRESPONDENCE,	WILLIAM ARC
LIBRARIAN,	JOHN T. GILB

Clerk of the Academy, (elected annually by the Academy)	EDWARD CLIB
Curator, Museum-Clerk, and Housekeeper,	CAPT. ROBERT
Irish Scribe,	MR. JOSEPH
Assistant Accountant,	MR. EDWARD S
Library Clerk,	MR. J. J. M
Assistant in Library,	MR. R. J. O'
Serjeant-at-Mace,	MR. J. J. M

Committees appointed by Coun

EMBERS OF THE ROYAL IRISH ACADEMY.

ORDINARY MEMBERS.

he sign * is prefixed to the names of Life Members.
he sign † indicates the Members who have not yet been formally admitted.
.B.—The names of *Members whose addresses are not known* to the Secretary of Academy, are printed in italics. He requests that they may be communicated im.

ate of Election.	
6. Jan. 8	Adams, Rev. Benjamin William, D.D. *The Rectory, Santry, Co. Dublin.*
3. April 10	*Allman, George James, Esq., M.D. (Dub. and Oxon.), Pres. Lin. Soc., F.R.C.S.I., F.R.SS., Lond. & Edin. *Upper Phillimore Gardens, London, S.W.*
1. June 12	*†Amherst, William Amhurst Tyssen-, Esq., D.L., F.S.A., M.R.S.L. *Didlington Hall, Brandon, Norfolk.*
3. Jan. 13	Andrews, Arthur, Esq. *Newtown House, Blackrock, Co. Dublin.*
9. Jan. 14	*Andrews, Thomas, Esq., M.D., LL.D. (Edin.), F.R.S., Hon. F.R.S. Ed., F.C.S., Vice-President, and Professor of Chemistry, Queen's College, Belfast. *Queen's College, Belfast.*
2. Jan. 10	*Andrews, William, Esq., F.R.G.S.I. *Ashton, The Hill, Monkstown, Co. Dublin.*
8. April 28	*Apjohn, James, Esq., M.D., F.R.S., F. and Hon. F., K. & Q.C.P.I., F.C.S., Professor of Mineralogy and of Applied Chemistry, Dublin Univ. *South Hill, Blackrock, Co. Dublin.*
0. Jan. 10	*Archer, William, Esq., F.R.S., Secretary of Foreign Correspondence. *St. Brendan's, Grosvenor-road, E., Rathmines, Co. Dublin.*
5. Mar. 16	*Ashburner, John, Esq., M.D., M.R.C. Phys. Lon. 7, *Hyde Park-place, London.*
5. Jan. 11	Atkinson, Robert, Esq., LL.D., Professor of Romance Languages, Univ. Dub., Secretary of Council of the Academy. 20, *Garville-avenue, Rathgar, Co. Dublin.*
2. April 8	Baily, William Hellier, Esq., F.L.S., F.G.S., Demonstrator in Palæontology, R.C.Sci.I. *Apsley Lodge*, 92, *Rathgar-road, Co. Dublin;* 14 *Hume-street, Dublin.*
5. June 11	Baker, John A., Esq., F.R.C.S.I. 4, *Clare-st., Dublin.*
2. June 24	Baldwin, Thomas, Esq. *Model Farm, Glasnevin, Co. Dublin.*

Date of Election.	
1840. April 13	*Ball, John, Esq., M.A., F.R.S., F.L.S *well Gardens, South Kensington, Lond*
1870. Jan. 10	Ball, Robert Stawell, Esq., LL.D., F.R Professor of Astronomy in the U Dublin, and Royal Astronomer of Ir tary of the Academy. *The Observato Co. Dublin.*
1842. Jan. 10	*Banks, John T., Esq., M.D., F.K. & Q *Merrion-square, East, Dublin.*
1851. April 14	*Barker, John, Esq., M.D., F.R.C.S.I. 48, *Waterloo-road, Dublin.*
1868. Jan. 13	*Barker, W. Oliver, Esq., M.D., M.R *Gardiner's-row, Dublin.*
1874. May 11	Barrett, William F., Esq., F.R.C.S.E., Physics, Royal College of Science *pelier-parade, Monkstown, Co. Dublin.*
1866. May 14	Barrington, Sir John, D.L. *St. Anne Co. Dublin.*
1865. Jan. 9	*Beauchamp, Robert Henry, Esq. 11 *street, Dublin.*
1863. April 27	*Belmore, Right Hon. Somerset-Richar M.A., D.L., K.C.M.G. *Castle Coole, E*
1866. June 11	Bennett, Edward Hallaran, Esq., M.I F.R.C.S.I., F.R.G.S.I., Professor of Su University of Dublin. 26, *Fitzwi Lower, Dublin.*
1825. Nov. 30	*Benson, Charles, Esq., M.A., M.B., F.R. *Fitzwilliam-square, (West), Dublin.*
1851. June 8	†Beresford, Right Hon. and Most Rev. D.D., D.C.L., Lord Archbishop of A mate of all Ireland. *The Palace, Arm*
1846. April 13	*Bevan, Philip, Esq., M.D. (Dub.), Pro tomy and Fellow R.C.S.I. 52, *Fitzwill (West), Dublin.*
1843. Jan. 9	*Blacker, Stewart, Esq., M.A., J.P. *Carr Portadown.*
1876. Jan. 11	*Blake, John A., Esq., Inspector of Fish *Ely-place, Dublin.*
1871. Jan. 9	Bourke, Very Rev. (Canon) Ulick J., Pres Jarlath's College, Tuam. *St. Jarlath's*
1873. April 14	†Boyd, Michael A., Esq., F.R.C.S.I., L.K. 90, *George's-street, Upper, Kingstown,*
1854. April 10	*Brady, Cheyne, Esq. *(Abroad.)*
1849. April 9	*Brady, Daniel Fredk., Esq., F.R.C.S.I., *La Choza, Rathgar-road, Co. Dublin.*
1858. April 12	†Brooke, Thomas, Esq., D.L. *The Castle, Strabane, Co. Donegal.*

Date of Election.	
1851. Jan. 13	*Browne, Robert Clayton, Esq., M.A., D.L. *Browne's Hill, Carlow.*
1874. Feb. 9	†Burden, Henry, Esq., M.A., M.D., M.R.C.S.E. 9, *College-square, North, Belfast.*
1854. April 10	Burke, Sir John Bernard (Ulster), LL.D., C.B. *Tullamaine Villa, Leeson-street, Upper, Dublin.*
1878. Feb. 11	†Burton, Charles E., A.B., F.R.A.S. *Observatory, Dunsink, Co. Dublin.*
1855. Jan. 8	*Butcher, Richard G., Esq., M.D., F.R.C.S.I., M.R.C.S.E. 19, *Fitzwilliam-street, Lower, Dublin.*
1866. April 9	Byrne, John A., Esq., B.A., M.B. (Dub.) 37, *Westland-row, Dublin.*
1876. May 8	Byrne, William H., Esq., C.E. *Largo House, Rathmines, Co. Dublin.*
1862. April 14	Campbell, John, Esq., M.D., Professor of Chemistry, C.U.I. 36, *Leinster-road, Rathmines, Co. Dublin.*
1873. May 12	†Carlingford, Right Hon. Chichester, Baron, D.L., Lord Lieutenant of Essex. *Red House, Ardee; 7, Carlton Gardens, London, S.W.*
1838. Feb. 12	*Carson, Rev. Joseph, D.D., S.F.T.C.D., F.R.G.S.I. 18, *Fitzwilliam-place, Dublin.*
1855. Feb. 12	Carte, Alexander, Esq., M.D., F.R.C.S.I., F.R.G.S.I., Director of the Royal Dublin Society's Museum of Natural History. 14, *Northbrook-road, Dublin.*
1876. Jan. 11	†Carton, Richard Paul, Esq., Q.C. 35, *Rutland-square (West), Dublin.*
1866. May 14	Casey, John, Esq., LL.D., F.R.S., Professor of Higher Mathematics and Mathematical Physics, C.U.I. *Iona-terrace, Circular-road (South), Dublin.*
1873. Jan. 13	†Castletown of Upper Ossory, Right Hon. John-Wilson, Baron, Lieutenant of the Queen's County. *Lisduff, Errill, Templemore.*
1862. Jan. 13	*†Cather, Rev. Robert G., LL.D. *Nutty Hagg, Wandsworth Common, London, S.W.*
1843. Jan. 8	*Cather, Thomas, Esq., J.P. *Newtownlimavady.*
1842. June 13	*Chapman, Sir Benjamin J., Bart., D.L. *Killua Castle, Clonmellon.*
1864. Jan. 11	Charlemont, Right Hon. James-Molyneux, Earl of, K.P., Lieutenant of the County Tyrone. *Roxborough Castle, Moy, Co. Armagh.*
1876. April 10	*Clarke, Francis E., M.A., M.D., L.K.Q.C.P.I., M.R.C.S.E. 28, *Lawrence-street, Drogheda.*
1857. April 13	*†Cleland, James, Esq., J.P. *Tobar Mhuire, Crossgar, Co. Down.*
1842. Jan. 10	**Clendinning*, Alex., Esq.

Date of Election.	
1841. Jan. 11	*†Clermont, Right Hon. Thomas, Baron, D.L. *Ra dale Park, Newry.*
1867. May 13	*Close, Rev. Maxwell H., M.A., F.R.G.S.I. 40 *Ba street, Lower, Dublin.*
1835. Nov. 30	**Cole*, Owen Blayney, Esq., D.L.
1874. June 8	Collins, Edward Wolfenden, Esq., M.D. 33, *Ba street, Lower, Dublin.*
1866. April 9	†Cooper, Lieut. Col. Edward H., D.L. *MarkreeC Collooney.*
1856. April 14	Copland, Charles, Esq. *Royal Bank, Foster-place, lin; 7, Longford-terrace, Monkstown, Co. Du*
1825. Nov. 30	*Corballis, John R., Esq., LL.D., Q.C. *Rosem Roebuck, Clonskeagh, Co. Dublin.*
1847. Jan. 11	*Corrigan, Sir Dominic J., Bart., M.D., F.K.&Q.C. For. Corr. Mem. Academie de Medecine, P 4, *Merrion-square, West, Dublin.*
1864. May 9	†Cotton, Charles Philip, Esq., B.A., C.E., F.R.G 11, *Pembroke-street, Lower, Dublin.*
1846. Jan. 12	Cotton, Rev. Henry, LL.D., D.C.L. (late Archde of Cashel.) *Lismore.*
1876. Apr. 10	Cox, Michael Francis, Esq., M.A., L.R.C. *Sligo.*
1857. Aug. 24	*Crofton, Denis, Esq., B.A. 8, *Mountjoy-sq (North), Dublin.*
1867. June 24	*†Crofton, Henry Morgan E., Esq., F.R.A.S., *Inchinappa, Ashford, Co. Wicklow.*
1866. June 11	Cruise, Francis R., Esq., M.D., F.K. & Q.C. M.R.C.S.E. 3, *Merrion-square, West, Dublin*
1870. Apr. 11	Cruise, Richard Joseph, Esq., F.R.G.S.I., Geolo Survey of Ireland. *Boyle, Co. Roscommon; Hume-street, Dublin.*
1874. June 8	Cryan, Robert, Esq., M.D. 54, *Rutland-square, (W Dublin.*
1876. Nov. 13	*†Dalway, Marriott R., Esq., M.P. *Bella I Carrickfergus.*
1853. April 11	*Davies, Francis Robert, Esq., K.J.J. *Hawth Blackrock, Co. Dublin.*
1855. May 14	*Davy, Edmund W., Esq., M.A., M.D., Prof. Med. Jurisprudence, R.C.S.I. *Fortfield Terr Templeogue, Co. Dublin.*
1846. April 13	*D'Arcy, Matthew P., Esq., M.A., D.L. 6, *Merri square, East, Dublin.*
1870. Jan. 10	Day, Robert, Jun., Esq., F.S.A. *Sidney-place, Co*
1876. Jan. 11	Deane, Thomas Newenham, Esq. R.H.A., F.R.I.A 3, *Merrion-street, Upper, Dublin.*

Date of Election.	
1846. Jan. 12	*Deasy, Right Hon. Rickard, LL.D., Third Baron of the Exchequer. *Carysfort House, Blackrock, Co. Dublin.*
1851. June 9	*†De la Ponce, Mons. Amadie. *Paris.*
1860. Jan. 9	*Dickson, Rev. Benjamin, D.D., F.T.C.D. 3, *Kildare-place, Dublin.*
1876. Feb. 14	Dillon, William, Esq. 2, *George's-street, Great, North, Dublin.*
1876. Jan. 11	*Doberck, William, Esq., Ph.D. *Observatory, Markree, Collooney.*
1847. Jan. 11	*†Dobbin, Leonard, Esq. 27, *Gardiner's-place, Dublin.*
1851. Jan. 13	*Dobbin, Rev. Orlando T., LL.D. *Sutton, Co. Dublin.*
1856. Feb. 11	Downing, Samuel, Esq., C.E., LL.D., F.R.G.S.I., Professor of Civil Engineering, Dublin Univ. 4, *The Hill, Monkstown, Co. Dublin.*
1876. June 26	†Draper, Harry N. Esq., F.C.S. *Palmerston-park, Rathmines, Co. Dublin.*
1873. Jan. 13	Drew, Thomas, Esq., R.H.A., F.R.I.A.I. 6, *St. Stephen's-green, (North), Dublin.*
1843. Jan. 9	*Drury, William Vallancey, Esq., M.D. 7, *Harley-street, Cavendish-square, London, W.*
1861. Feb. 11	Duncan, James Foulis, Esq., M.D., F.K. & Q.C.P.I. 8, *Merrion-street, Upper, Dublin.*
1873. Jan. 13	Durham, James Samuel William, Esq., F.R.G.S.I. *Rosenthal, Torquay, South Devon.*
1843. Dec. 11	*†Eiffe, James S., Esq., F.R.Ast.S. *The Laurels, Yiewsley, West Drayton, England.*
1867. Feb. 11	Ellis, George, Esq., M.B., F.R.C.S.I. 91, *Leeson-street, Lower, Dublin.*
1841. April 12	*Emly, Right Hon. William, Baron, Lieutenant of the County Limerick. *Tervoe, Limerick; Athenæum Club, London, S.W.*
1846. Jan. 12	*Enniskillen, Right. Hon. William-Willoughby, Earl of, LL.D., D.C.L., D.L., F.R.S., F.R.G.S.I., one of the Trustees of the Hunterian Museum, R.C.S., London. *Florence Court, Co. Fermanagh; 65, Eaton-place, London, S.W.*
1867. April 8	*Farrell, Thomas A., Esq., M.A. 3, *Merrion-square, East, Dublin.*
1834. Mar. 15	*Ferguson, Samuel, Esq., LL.D., Q.C., a Vice-President of the Academy. 20, *George's-street, Great, North, Dublin.*
1842. Jan. 10	*Ferrier, Alexander, Esq. *Knockmaroon Lodge, Chapelizod, Co. Dublin.*
1878. Feb. 11	Fitzgerald, George F., Esq., M.A., F.T.C.D. 16, *Trinity College, Dublin.*

Date of Election.	
1857. Aug. 24	Fitzgerald, Right Rev. William, D.D., Lord Bish of Killaloe, &c. *Clarisford House, Killaloe.*
1870. May 23	†FitzGibbon, Abraham, Esq., M.I.C.E. Lond. *Th Rookery, Great Stanmore, Middlesex.*
1841. April 12	*Fitzgibbon, Gerald, Esq., M.A., Master in Chancer 10, *Merrion-square, North, Dublin.*
1875. Jan. 11	Fitzpatrick, William John, Esq., J.P., LL.D. 1 *Pembroke-road, Dublin.*
1860. Jan. 9	Foley, William, Esq., M.D., M.R.C.S.E. *Kilrush*
1874. May 11	Foot, Arthur Wynne, Esq., M.D., F.K.Q.C.P.I. F.R.G.S.I. 49, *Leeson-street, Lower, Dublin.*
1874. Feb. 9	†Foster, Rev. Nicholas. *Ballymacelligott Rectory, Tral*
1876. Feb. 14	Fottrell, George, Esq. 8, *George's-street, Grea North, Dublin.*
1838. Nov. 12	**Frazer*, George A., Esq., Captain R.N.
1866. May 14	Frazer, William, Esq., F.R.C.S.I., F.R.G.S.I. 2 *Harcourt-street, Dublin.*
1865. April 10	†Freeland, John, Esq., M.D. *Antigua, West Indie*
1847. May 10	*Freke, Henry, Esq., M.D. (Dub.), F.K.&Q.C.P.I. 68, *Mount-street, Lower, Dublin.*
1873. April 14	*†Frost, James, Esq., J.P. *Ballymorris, Cratloe, Co. Clare.*
1875. June 14	Furlong, Nicholas, Esq., M.D. *Symington, Ennis-corthy.*
1859. Jan. 10	Gages, Alphonse, Esq., Chev. L.H., F.R.G.S.I. *Royal College of Science, 51 St. Stephen's-green, (East), Dublin*
1845. April 14	*Galbraith, Rev. Joseph Allen, M.A., F.T.C.D., F.R.G.S.I. 8, *Trinity College, Dublin.*
1866. June 11	†Gallwey, Thomas, Esq., J.P. 42, *Harcourt-street, Dublin.*
1864. Jan. 11	Garnett, George Charles, Esq., M.A. 5, *Mountjoy-square, (North), Dublin.*
1863. Feb. 9	*Garstin, John Ribton, Esq., M.A., LL.B., F.S.A., F.R. Hist. Soc., Hon. F.R.I.A.I., J.P., Treasurer of the Academy. *Green-hill, Killiney, Co. Dublin.*
1851. Jan. 13	Gibson, James, Esq., M.A., Q.C. 35, *Mountjoy-square, (South), Dublin.*
1855. April 9	*Gilbert, John Thomas, Esq., F.S.A., R.H.A. Librarian of the Academy. *Villa Nova, Black-rock, Co. Dublin.*
1876. May 8	Gillespie, William, Esq. *Racefield House, Kingstown, Co. Dublin.*
1875. April 12	*†Gore, J. E., Esq., C.E., A.I.C.E., F.R.A.S. F.R.G.S.I. *Dromard, Ballisodare, Co. Sligo.*
1836. May 25	*Gough, Right Hon. George S., Viscount, M.A., D.L. F.L.S., F.G.S. *St. Helen's, Booterstown, Co. Dublin.*

Date of Election.	
1848. June 12	*Graham, Andrew, Esq. *Observatory, Cambridge.*
1848. April 10	*Graham, Rev. William. *Dresden.*
1876. April 10	†Grainger, Rev. John, D.D. *Broughshane, Co. Antrim.*
1863. April 13	†Granard, Right Hon. George-Arthur-Hastings, Earl of, K.P. *Castle Forbes, Co. Longford.*
1837. April 24	*Graves, Right Rev. Charles, D.D., Lord Bishop of Limerick, &c. *The Palace, Henry-street, Limerick.*
1874. Feb. 9	Gray, William, Esq. 6, *Mount-Charles, Belfast.*
1867. April 8	Green, James S., Esq. Q.C. 83, *Leeson-street, Lower, Dublin.*
1872. April 8	†Greene, John Ball, Esq., C.E., F.R.G.S.I., Commissioner of Valuation. 6, *Ely-place, Dublin.*
1819. April 26	*Griffith, Sir Richard, Bart., LL.D., F.R.S.Ed., F.G.S., V.P.R.G.S.I. 2, *Fitzwilliam-place, Dublin.*
1842. Jan. 10	*Grimshaw, Wrigley, Esq., F.R.C.S.I. 4, *Brighton-terrace, Bray.*
1857. June 8	*Griott, Daniel G., Esq., M.A. 9, *Henrietta-street, Dublin.*
1839. Jan. 14	*Grubb, Thomas, Esq., F.R.S. 141, *Leinster-road, Rathmines, Co. Dublin.*
1870. April 11	†Guinness, Sir Arthur E., Bart., M.A., M.P., D.L. 18, *Leeson-street, Lower; St. Anne's, Clontarf, Co. Dublin.*
1873, Dec. 8	*Guinness, Edward Cecil, Esq. M.A., D.L. 80, *St. Stephen's-green (South), Dublin.*
1836. April 25	*Hamilton, Charles William, Esq., J.P. 40, *Dominick-street, Lower, Dublin.*
1875. Jan. 11	Hamilton, Edward, M.D., F.R.C.S.I. 120, *St. Stephen's-green, (West), Dublin.*
1867. April 8	*Hanagan, Anthony, Esq. *Luckington, Dalkey, Co. Dublin.*
1847. Jan. 11	Hancock, William Neilson, Esq., LL.D. 64B, *Gardiner-street, Upper, Dublin.*
1850. April 8	*Hardinge, William Henry, Esq. 20, *Clarinda Park, East, Kingstown, Co. Dublin.*
1837. Feb. 13	*Hart, Andrew Searle, Esq., LL.D., S.F.T.C.D. 71, *St. Stephen's-green, (South); Trinity College, Dublin.*
1874. Dec. 14	*Harvey, Reuben Joshua, Esq., M.D. 7, *Merrion-street, (Upper), Dublin.*
1861. May 13	Hatchell, John, Esq., M.A., J.P. 12, *Merrion-square, South, Dublin.*
1857. Aug. 24	Hayden, Thomas, Esq., F.K.&Q.C.P.I., Prof. of Anatomy and Physiology, C. U.I., a Vice-President of the Academy. 18, *Merrion-square, North, Dublin.*

Date of Election.	
1837. Feb. 13	**Knox*, George J., Esq.
1835. Nov 30.	*Kyle, William Cotter, Esq., LL.D. 8, *Clare-st., Dublin*
1864. April 11	*Lalor, John J., Esq., F.R.G.S.I. *City Hall, Cork-hill, Dublin.*
1875. May 10	†Lane, Alexander, Esq., M.D. *Ballymoney.*
1833. Nov. 30	*Larcom, Right Hon. Sir Thomas Aiskew, Bart. Major-General, K.C.B., R.E., LL.D., F.R.S. F.R.G.S.I., an Honorary Member of the Academy *Heathfield, Fareham, Hants.*
1864. Jan. 11	LaTouche, J. J. Digges, Esq., M.A. 1, *Ely-place Upper, Dublin.*
1836. Jan. 25	*LaTouche, William Digges, Esq., M.A., D.L. 3 *St. Stephen's-green, (North), Dublin.*
1857. May 11	*Lawson, Right Hon. James A., LL.D., Justice of the Court of Common Pleas. 27, *Fitzwilliam-street Upper, Dublin.*
1857. April 13	*Leach, Lieut.-Colonel George A., R.E. 3, *St. James's square, London, S.W.*
1839. May 13	*†Leader, Nicholas P., Esq., J.P. *Dromagh Castle Kanturk.*
1852 May 10	Leared, Arthur, Esq., M.D. (Dub.), F.R.C.P. Lond and Physician to the Great Northern Hospital 12, *Old Burlington-street, London, W.*
1845. Feb. 10	*LeFanu, William R., Esq., C.E. *Summerhill Enniskerry, Co. Wicklow.*
1846. May 11	*Lefroy, George, Esq. *(Abroad.)*
1844. April 8	*†Leinster, His Grace Charles-William, Duke of Chancellor of the Queen's University in Ireland and President of the Royal Dublin Society. *Carton, Maynooth.*
1828. April 28	*†Lenigan, James, Esq., M.A., D.L. *Castle Fogarty Thurles.*
1869. April 12	*Lenihan, Maurice, Esq., J.P. *Limerick.*
1853. April 11	Lentaigne, John, Esq., C.B., M.B., J.P., F.R.G.S.I. 1, *Denmark-street, Great, Dublin.*
1870. June 13	Leonard, Hugh, Esq., F.G.S., F.R.G.S.I. *Geological Survey of Ireland*, 14, *Hume-street, Dublin.*
1868. April 27	*Little, James, Esq., M.D., L.R.C.S.I., F.K. Q.C.P.I. 24, *Baggot-street, Lower, Dublin.*
1877. May 14	†Lloyd, Christopher, Esq., M.D., Surgeon, H.M. Madras Army. 31*st Madras Light Infantry Rnipore, India.*
1832. Feb. 27	*Lloyd, Rev. Humphrey, D.D., D.C.L. (Oxon.), F.R.S. Lond. and Edin., V.P.R.G.S.I., V.P.R.D.S., Member of the German Order "For Merit," Provost of Trinity College, Dublin. *Provost's House, Dublin; Victoria Castle, Killiney, Co. Dublin.*

Date of Election.	
1876. Jan. 11	Lloyd, Joseph Henry, Esq., M.A., Ph. D., F.R.S.L., F.S.A., M. Phil. Soc. *Chalgrove, Circular-road, South, Dublin.*
1846. Jan. 12	*Lloyd, William T., Esq., M.D. *London.*
1875. April 12	Lombard, James F., Esq., J.P. *South-hill, Rathmines, Co. Dublin.*
1845. Feb. 10	*Longfield, Rev. George, D.D., F.T.C.D. 1, *Earlsfort-terrace, Dublin.*
1838. Feb. 12	*†Longfield, Right Hon. Mountifort, LL.D. (late Judge in the Landed Estates' Court). 47, *Fitzwilliam-square, (West), Dublin.*
1878. Feb. 11	†Lowry, Robert William, Esq., B.A. (Oxon.) D.L., J.P. *Pomeroy House, Dungannon, Co. Tyrone.*
1868. Jan. 13	Lyne, Robert Edwin, Esq. *Sandymount, Co. Dublin.*
1851. May 12	*Lyons, Robert D., Esq., M.B., F.K. & Q.C.P.I., Prof. of Medicine, C.U.I. 8, *Merrion-square, West, Dublin.*
1873. April 14	Macalister, Alexander, Esq., M D., L.R.C.S.I., L.K. & Q.C.P.I., F.R.G.S.I., Professor of Comparative Anatomy and Zoology in the University of Dublin. 15. *Palmerston-road, Upper Rathmines, Co. Dublin.*
1871. Feb. 13	*Macartney, J. W. Ellison, Esq., M.P., J.P. *The Palace, Clogher.*
1857. April 13	Mac Carthy, Denis Florence, Esq. 21, *Notting-hill Terrace, London, W.*
1853. April 11	*McCarthy, James Joseph, Esq., R.H.A. *Charleston House, Rathmines, Co. Dublin.*
1875. Jan. 11	†Mac Carthy, John G., Esq., M.P. *River View, Montenotte, Cork.*
1874. Feb 9	McClure, Rev. Edmund, M.A. 67, *Lincoln's-Inn Fields, London, W.C.*
1873. Jan. 13	*McCready, Rev. Christopher, M.A. 56, *High-street, Dublin.*
1864. April 11	*McDonnell, Alexander, Esq., M.A., C.E., F.R.G.S.I. *St. John's, Island-bridge, Co. Dublin.*
1825. Feb. 24	**Macdonnell*, James S., Esq., C.E.
1827. Mar. 16	*Mac Donnell, John, Esq., M.D., F.R.C.S.I., F.R.G.S.I. 32, *Fitzwilliam-street, Upper, Dublin.*
1857. Feb. 9	*McDonnell, Robert, Esq., M.D., President and Fellow R.C.S.I., F.R.S. 14, *Pembroke-street, Lower, Dublin.*
1865. April 10	†Mac Donnell, Lieut.-Col. William Edward Armstrong, Vice-Lieutenant of the County Clare. *New Hall, near Ennis.*
1856. June 9	*Mac Ivor, Rev. James, D.D., F.R.G.S.I. *Moyle, Newtownstewart.*

Date of Election.	
1876. April 10	McIlwaine, Rev. William, D.D. *Ulster Villas, Belfast.*
1871. April 10	Macnaghten, Colonel Sir Francis Edmund, Bart. (Late 8th Hussars). *Dundarave, Bushmills, Co. Antrim.*
1831. Feb. 28	**Mac Neill,* Sir John, LL.D., F.R.S., F.R.A.S.
1874. April 13	McSwiney, Stephen Myles, Esq., M.D. 1, *Hume-street, Dublin.*
1846. Feb. 23	*Madden, Richard R., Esq., F.R.C.S. Eng. 1, *Vernon-terrace, Booterstown-avenue, Booterstown, Co. Dublin.*
1864. June 13	Madden, Thomas More, Esq., M.D., L.K.Q.C.P.I., M.R.C.S.E., Examiner in Midwifery, etc., Q.U.I. 33, *Merrion-square, South, Dublin.*
1870. Jan. 10	Mahaffy, Rev. John Pentland, M.A., F.T.C.D. 38, *George's-street, Great, North, Dublin.*
1874. Feb. 9	Malet, John Christian, Esq., M.A. *Trinity College, Dublin.*
1832. Oct. 22	*Mallet, Robert, Esq., M.A., M. Eng., Ph. D., M.I.C.E., F.R.S., F.G.S., F.R.G.S.I. 16, *The Grove, Clapham-road, London, S.*
1865. April 10	*†Malone, Rev. Silvester, P.P., F.R.H.A.A.I. *Six-milebridge.*
1859. Jan. 10	*Manchester, His Grace William-Drogo, Duke of. 1, *Great Stanhope-street, London; Kimbolton Castle, St. Neot's, Hunts; The Castle, Tanderagee.*
1828. Mar. 15	*Martin, Ven. John Charles, D.D., Archdeacon of Kilmore. *Killeshandra.*
1871. Jan. 9	Maunsell, George Woods, Esq., M.A., D.L., V.P. R.D.S. 10, *Merrion-square, South, Dublin.*
1876. April 10	†Meyers, Walter, Esq. 2, *Richard-street, Spencer-street, Birmingham.*
1861. Jan. 14	†Monck, Right Hon. Charles-Stanley, Viscount, G.C.M.G., Lieutenant of Dublin City and County. *Charleville, Bray, Co. Wicklow.*
1858. Jan. 11	**Montgomery,* Howard B., Esq., M.D.
1860. Jan. 9	Moore, Alexander G. Montgomery, Lieut.-Colonel, 4th Hussars. *India.*
1845. June 23	*Moore, David, Esq., Ph. D., F.L.S., Director of the Botanical Gardens, Glasnevin. *Glasnevin, Co. Dublin.*
1861. Jan. 14	Moore, James, Esq., M.D., M.R.C.S.E. 7, *Chichester-street, Belfast.*
1869. Feb. 8	*Moran, Most Rev. Patrick F., D.D., Bishop of Ossory. *St. Kyran's College, Kilkenny.*
1866. April 9	More, Alexander Goodman, Esq., F.L.S. 3, *Botanic View, Glasnevin, Co. Dublin.*
1874. Feb. 9	Moss, Richard J., Esq., Keeper of the Minerals, R.D.S. 66, *Kenilworth-square, Rathgar.*

Date of Election.	
1840 Feb. 10	*Napier, Right Hon. Sir Joseph, Bart., D.C.L., LL.D., Vice-Chancellor of Dublin University. 4, *Merrion-square, South, Dublin.*
1844. June 8	*Neville, John, Esq., C.E., F.R.G.S.I. *Roden-place, Dundalk.*
1854. May 8	Neville, Parke, Esq., C.E. 58, *Pembroke-road, Dublin.*
1872. June 24	Nolan, Francis, Esq., A.R.I.A.I. *Ardeevin, Glenageary, Kingstown, Co. Dublin.*
1873. Jan. 13	Nolan, Joseph, Esq., F.R.G.S.I., Geological Survey of Ireland. 14, *Hume-street, Dublin.*
1846. Jan. 12	*†Nugent, Arthur R., Esq. *(Portaferry, Co. Down).*
1869. June 14	*O'Brien, James H., Esq. *St. Lorcan's, Howth, Co. Dublin.*
1869. June 14	O'Callaghan, John Cornelius, Esq. 1, *Rutland-street, Upper, Dublin.*
1875. Jan. 11	O'Callaghan, J. J., Esq., F.R.I.A.I. 31 *Harcourt-street, Dublin.*
1867. June 10	O'Conor Don, The, D.L., M.P. *Clonalis, Castlerea, Co. Roscommon.*
1833. May 27	*O'Dell, Edward, Esq., J.P. *Carriglea, Dungarvan.*
1867. Jan. 14	O'Donel, Charles J. Esq., J.P. 47, *Leeson-street, Lower, Dublin.*
1865. Apr. 10	O'Donnavan, William J., Esq., LL.D. *University Club,* 17, *St. Stephen's-green, (North), Dublin;* 54, *Kenilworth-square, Rathgar, Co. Dublin.*
1869. Apr. 12	†O'Ferrall, Ambrose More, Esq. *Kildare-street Club, Dublin.*
1866. June 8	*O'Grady, Edward S., Esq., B.A., M.B., M. Ch., F.R.C.S.I. 105, *St. Stephen's-green, (South), Dublin.*
1867. May 13	†O'Grady, Standish H., Esq. *Polmont Park, Polmont, Scotland.*
1866. June 25	O'Hagan, John, Esq., M.A., Q.C. 22, *Fitzwilliam-street, Upper, Dublin.*
1857. June 8	O'Hagan, Right Hon. Thomas, Baron. 34, *Rutland-square, (West), Dublin.*
1869. Apr. 12	O'Hanlon, Rev. John. *Presbytery, Exchange-street, Lower, Dublin.*
1878. Feb. 11	†O'Hanlon, Michael, Esq., L.K. & Q.C.P.I. *Castlecomer, Co. Kilkenny.*
1866. Jan. 8	O'Kelly, Joseph, Esq., M.A., F.R.G.S.I., Geological Survey of Ireland. 7, *Warwick-terrace, Leeson Park, Dublin;* 14, *Hume-street, Dublin.*
1869. Apr. 12	O'Laverty, Rev. James, P.P. *Holywood, near Belfast.*
1876. Feb. 14	†Olden, Rev. Thomas, B.A. *Ballyclough, Mallow, Co. Cork.*

Date of Election.	
1844. June 10	*Oldham, Thomas, Esq., LL.D., F.R.S., F.G.S., Hon. F.R.G.S.I., Superintendent of the Geological Survey of India. *Calcutta.*
1871. Apr. 10	O'Looney, Brian, Esq., F.R.H.S., Professor of Irish Language, Literature, and Archæology to the Catholic University of Ireland, 85, St. Stephen's-green (South). *Grove-villa House, Crumlin, Co. Dublin.*
1861. June 10	*O'Mahony, Rev. Thaddeus, D.D., Prof. of Irish in Dublin University. 37, *Trinity College, Dublin.*
1870. Jan. 10	O'Reilly, Joseph P., Esq., C.E., Prof. of Mining and Mineralogy, Royal Coll. of Science, Dublin. 58, *Park-avenue, Sandymount, Co. Dublin.*
1866. June 11	O'Rourke, Rev. John. *St. Mary's, Maynooth.*
1838. Dec. 10	*Orpen, John Herbert, Esq., LL.D. 58, *Stephen's-green, (East), Dublin.*
1870. Feb. 14	O'Shaughnessy, Mark S., Esq., Regius Prof. of English Law, Queen's College, Cork, and one of the Examiners, Q.U.I. 19, *Gardiner's-place, Dublin.*
1866. Jan. 8	O'Sullivan, Daniel, Esq., Ph. D. 9, *Eden-park, Sandycove, Kingstown, Co. Dublin.*
1839. June 10	*Parker, Alexander, Esq., J.P. 46, *Upper Rathmines, Co. Dublin.*
1873. Feb. 10.	Patterson, William Hugh, Esq. *Dundela, Strandtown, Belfast.*
1847. Feb. 8	*†Pereira [elected as Tibbs], Rev. Henry Wall, M.A., F.S.A. Scot., &c. *Donnington Lodge, Iffley, Oxford.*
1872. Apr. 8	Phayre, Major-General Sir Arthur Purves, K.C.S.I., C.B., Governor of the Mauritius. "*Care of Messrs. H. S. King and Co.*, 45 *Pall Mall, London, S.W.*"
1841. Apr. 12	*Phibbs, William, Esq. *Seafield, Sligo.*
1863. Apr. 13	Pigot, David R., Esq., M.A., Master, Court of Exchequer. 12, *Leeson-park, Dublin.*
1870. Apr. 11	Pigot, Thomas F., Esq., C.E., Prof. of Descriptive Geometry, etc., Royal College of Science, Dublin. 4, *Wellington-road, Dublin.*
1838. Feb. 12	*Pim, George, Esq., J.P. *Brennanstown, Cabinteely, Co. Dublin.*
1849. Jan. 8	*Pim, Jonathan, Esq. *Greenbank, Monkstown, Co. Dublin.*
1851. Jan. 13	*Pim, William Harvey, Esq. *Monkstown House, Monkstown, Co. Dublin.*
1864. Jan. 11	*†*Poore*, Major Robert, (Late 8th Hussars). *(Abroad.)*
1862. Apr. 14	*Porte, George, Esq. 43, *Brunswick-st., Great, Dublin.*

Date of Election.	
1873. Jan. 13	*Porter, Alexander, Esq., M.D., F.R.C.S., Assist.-Surgeon, Indian Army. *Madras.*
1875. Jan. 11	†Porter, George Hornidge, Esq., M.D., Surgeon in Ordinary to the Queen in Ireland, M. Ch. (Hon. Caus.). 3, *Merrion-square, North, Dublin.*
1852. Apr. 12	*Porter, Henry J. Ker, Esq. *Hanover-square Club, London, W.*
1836. Apr. 25	*Porter, Rev. Thomas Hamblin, D.D. *Ballymully Glebe, Tullyhogue, Dungannon.*
1873. Jan. 13	Powell, George Denniston, Esq., M.D., L.R.C.S.I. 76, *Leeson-street, Upper, Dublin.*
1864. June 13	†Power, Sir Alfred, K.C.B., M.A., Vice-President of the Local Government Board for Ireland. 35, *Raglan-road, Dublin.*
1875. April 12	*†Powerscourt, The Right Hon. Mervyn Wingfield, Lord Viscount. *Powerscourt, Enniskerry, Bray.*
1854. June 9	Pratt, James Butler, Esq., C.E. *Drumsna, Co. Leitrim.*
1874. Dec. 14	*†Purcell, Mathew John, Esq. *(Burton, Co. Cork).*
1858. Jan. 11	Purser, John, jun., Esq., M.A. *Lota, Blackrock, Co. Dublin;* 6, *Mountpleasant, Belfast.*
1867. Jan. 14	*†Read, John M., General, U.S.; Consul-General of the U.S.A. for France and Algeria, Member of American Philos. Soc., Fellow of the Royal Soc. of Northern Antiquaries, &c. *Athens.*
1877. April 9	†Reade, Rev. George H., J.P. *Greythorn, Glenageary, Kingstown.*
1846. Dec. 14	*Reeves, Very Rev. William, D.D., M.B., LL.D., Dean of Armagh. *The Public Library, Armagh; Rectory, Tynan.*
1843. Feb. 13	**Renny*, Henry L., F.R.G.S.I., Lieut. R.E., (Retired List). [*Quebec.*?]
1875. Jan. 11	Reynolds, James Emerson, Esq., M.D., Professor of Chemistry in the University of Dublin. 62, *Morehampton-road, Dublin.*
1867. Apr. 8	Richey, Alexander George, Esq., LL.D., Q.C., a Vice-President of the Academy. 27, *Pembroke-street, Upper, Dublin.*
1875. June 14	Robertson, John C., Esq., L.K.Q.C.P.I., M.R.S.I. *The Asylum, Monaghan.*
1816. Feb. 14	*Robinson, Rev. Thomas Romney, D. D., F. R. S., F.R.Ast.S., Hon. M.I.C.E.Lon., Hon. M.I.C.E.I., Hon. M. Cambridge Phil. Soc., Hon. M. Acad. Palermo, Hon. M. Acad. Philadelphia, Hon. F. R.G.S.I., Royal Medallist, R.S., 1862, Director of Armagh Observatory. *Observatory, Armagh.*
1844. June 10	*Roe, Henry, Esq., M.A. *(Isle of Man.)*

Date of Election.	
1876. Jan. 11	*†Ross, Rev. William. *Chapel Hill House,*
1870. Nov. 30	Rosse, Rt. Hon. Lawrence, Earl of, D.L V.P.R.S., F.R. Ast. S. *Birr Castle, Pa*
1872. Apr. 8	†Rowley, Standish G., Esq., J.P., M.R.S.I *Park, Kells, Co. Meath.*
1868. Feb. 10	Russell, Very Rev. Charles William, D.] dent of the Royal College of St. Patr nooth. *The College, Maynooth.*
1843. Jan. 9	*Salmon, Rev. George, D.D., D.C.L. (Oxor (Cantab.), F.R.S., and Royal Medalli Regius Professor of Divinity in the Uni Dublin. 81, *Wellington-road, Dublin.*
1853. Jan. 10	*Sanders, Gilbert, Esq. *Albany Grove, M County Dublin.*
1851. May 12	*Sayers, Rev. Johnston Bridges, LL.D. *Velor*
1848. Feb. 14	†Segrave, O'Neal, Esq., D.L. *Kiltimon, mountkennedy.*
1846. Feb. 9	*†Sherrard, James Corry, Esq. 7, *Oxfo Hyde-park, London.*
1873. Jan. 13	*†Shirley, Evelyn Philip, Esq., M.A., D.I *Lough Fea, Carrickmacross; Lower Park, Stratford-on-Avon.*
1847. Jan. 11	*Sidney, Frederick J., Esq., LL.D., F.R.G. retary of the Royal College of Science, 19, *Herbert-street, Dublin.*
1869. Apr. 12	Sigerson, George, Esq., M.D., M.Ch., F.L. of Botany, C.U.I. 3, *Clare-street, Dubl*
1861. Apr. 8	Sloane, John Swan, Esq., C.E. *Balmor Castle Avenue, Co. Dublin;* 21, *Westmorela Dublin.*
1835. Feb. 23	*Smith, Aquilla, Esq., M.D., F.K. & King's Prof. of Materia Medica and Pl Dub. Univ. 121, *Baggot-street, Lower, I*
1877. Dec. 10	*†Smith, Charles, Esq. *Barrow-in-Furness.*
1868. Jan. 13	†Smith, John Chaloner, Esq., C.E. *Enginee Dublin, Wicklow and Wexford Railway, B*
1833. Apr. 22	*Smith, Joseph Huband, Esq., M.A.
1876. June 26	Smith, Rev. Richard Travers, (Canon) B.] *Vicarage, Clyde-road, Dublin.*
1873. Jan. 13	Smyth, Patrick James, Esq., M.P., Chev 15, *Belgrave-square, East, Rathmines, Co. I*
1867. Jan. 14	Smythe, William Barlow, Esq., M.A., D.L *villa House, Collinstown, Killucan.*
1873. April 14	*Smythe, William James, Lieutenant-Gener F.R.S. *White Abbey, Belfast.*
1846. Apr. 13	*Stapleton, Michael H., Esq., M.B., F. 1, *Mountjoy-place, Dublin.*

Date of Election.	
1853. Apr. 11	*Stewart, Henry H., Esq., M.D., F.R.C.S.I. 75, *Eccles-street, Dublin.*
1874. Dec. 14	Stewart, James, Esq., M.A. (Cantab.), Professor of Greek and Latin, C.U.I. 21, *Gardiner's-place, Dublin.*
1871. June 12	Stokes, Whitley, Esq., LL.D., Secretary to the Supreme Council of India. *Legislative Council House, Calcutta.*
1874. June 22	Stokes, William, Esq., M.D., M. Ch. 5, *Merrion-square, North, Dublin.*
1857. June 8	*Stoney, Bindon B., Esq., C.E., F.R.G.S.I. 42, *Wellington-road, Dublin.*
1856. Apr. 14	Stoney, George Johnstone, Esq., M.A., F.R.S., Secretary to the Queen's University in Ireland. *Palmerston-road, Co. Dublin.*
1857. Aug. 24	*Sullivan, William Kirby, Esq., Ph.D., President of Queen's College, Cork. *Queen's College, Cork.*
1874 Apr. 13	†Sweetman, H. S., Esq. 38, *Alexandra-road, St. John's Wood, London, N.W.*
1845. Feb. 24	*Sweetman, Walter, Esq., J.P. 4, *Mountjoy-square, (North), Dublin.*
1871. Jan. 9	†Symons, John, Esq. 72, *Queen-street, Hull.*
1845. June 23	*Talbot de Malahide, Right Hon. James, Baron, D.C.L., D.L., F.R.S., F.S.A., F.G.S., F.R.G.S.I., F.R. Hist. Soc., Pres. Archæol. Inst. *The Castle, Malahide, Co. Dublin.*
1877. April 9	Tarleton, Francis Alexander, LL.D., F.T.C.D. 24, *Leeson-street, Upper, Dublin.*
1848. Feb. 14	*†Tarrant, Charles, Esq., C.E. *Waterford.*
1846. Jan. 12	*Tenison, Colonel Edward King, M.A., Lieutenant of the County Roscommon. *Kilronan Castle, Keadue, Carrick-on-Shannon.*
1866. June 11	†Thom, Alexander, Esq., J.P. *Donnycarney House, Artane, Co. Dublin.*
1869. Apr. 12	Tichborne, Charles Roger C., Esq., F.C.S.I. 23, *Gardiner-street, Middle, Dublin; Apothecaries' Hall,* 40, *Mary-street, Dublin.*
1869. June 14	Tobin, Sir Thomas, F.S.A., D.L. *Ballincollig, Cork.*
1864. Mar. 16	Trench, Right Hon. and Most Rev. Richard-Chenevix, D.D., Lord Archbishop of Dublin, Primate of Ireland. *The Palace, St. Stephen's-green, (North), Dublin.*
1846. Feb. 9	*Tuffnell, Thomas Joliffe, Esq., F.R.C.S.I., M.R.C.S.E. 58, *Mount-street, Lower, Dublin.*
[1]816. Feb. 14	**Turner,* William, Esq.

Date of Election.	
1871. June 12	†Tyrrell, Colonel Frederick, J.P. *Gold Coast Colony Accra, care of Forbes & Co., 25, Cockspur-street London, S.W.*
1876. April 10	*†Tyrrell, George Gerald, Esq., Clerk of the Crown Co. Armagh. *Banville, Banbridge, Co. Down.*
1834. May 26	*Vandeleur, Colonel Crofton M., D.L. 4, *Rutland square, (East), Dublin,*
1870 Nov. 30	†Ventry, Right Hon. Dayrolles-Blakeney, Baron, D.L. *Burnham-house, Dingle, Co. Kerry.*
1873. Jan. 13	†Ward, Robert Edward, Esq., D.L. *Bangor Castle, Bangor, Belfast.*
1864. Feb. 8	*†Warren, James W., Esq., M.A. 39 *Rutland-square (West), Dublin.*
1873. June 23	Warren, William H., Esq., M.D., L.R.C.S.I., L.K. & Q. C. P. I. 37, *Westland-row, Dublin; P. and O. Steam Nav. Co., Southampton.*
1866. Apr. 9	Westropp, W. H. Stacpoole, Esq., L.R.C.S.I. F.R.G.S.I., &c. *Lisdoonvarna, Co. Clare.*
1876. Nov. 13	†White, Rev. Hill Wilson. *Navan College, Navan.*
1857. June 8	*Whitehead, James, Esq., M.D., F.R.C.S.E., M.R.C Phys., Lon. 87, *Mosley-street, Manchester.*
1851. Jan. 13	*†Whittle, Ewing, Esq., M.D., M.R.C.S.E. 1, *Parliament-terrace, Liverpool.*
1874. June 8	Wigham, John R., Esq. 35, *Capel-street, Dublin.*
1862. Jan. 13	Wilkie, Henry, Esq. *Belgrave House, Monkstown avenue, Co. Dublin.*
1873. April 14	†Wilkinson, Thomas, Esq. *Enniscorthy, Co. Wexford*
1839. Jan. 14	*Williams, Richard Palmer, Esq., F.R.G.S.I. 38 *Dame-street., Dublin.*
1837. Jan. 9	*Williams, Thomas, Esq. 38, *Dame-street, Dublin.*
1877. April 9	†Williamson, Benjamin, M.A., F.T.C.D. 11, *Northbrook-road, Dublin.*
1855. Nov. 12	*Wright, Edward, Esq., LL.D. 16, *Hyde-Gardens Eastbourne.*
1857. Aug. 24	*Wright, Edward Perceval, Esq., M.A., M.D., F.L.S. F.R.C.S.I., Professor of Botany and Keeper of the Herbarium, Dublin University. 5, *Trinity College Dublin.*

HONORARY MEMBERS.

of Election.	
. June 22	HIS ROYAL HIGHNESS ALBERT-EDWARD, PRINCE OF WALES.

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he PRESIDENT OF THE ROYAL SOCIETY, AND EX-PRESIDENTS *of the same,* *e always considered Honorary Members of the Academy.*"—By-Laws, ii., 14.

. Mar. 16 (…d Hon. Mem. …ec. of Science …nally.)	Hooker, Sir Joseph Dalton, M.D., K.C.B., F.R.S., D.C.L., LL.D., V.P.L.S., F.G.S., Director of the Royal Gardens, Kew, PRESIDENT OF THE ROYAL SOCIETY. *Kew, London, W.*
. Mar. 16	Sabine, General Sir Edward, R.A., K.C.B., D.C.L., LL.D., V.P. and EX-PRESIDENT OF THE ROYAL SOCIETY, Hon. F.R.S., Edin., F.R.A.S., F.L.S., &c. 13, *Ashley-place, Westminster, London, S.W.*
. Nov. 30 (…d Hon. Mem. …ec. of Science …nally.)	Airy, Sir George Biddell, K.C B., D.C.L., LL.D., EX-PRESIDENT OF THE ROYAL SOCIETY (1871), Astronomer Royal, V.P. R. Ast. S., &c. *The Royal Observatory, Greenwich, London, S.E.*

SECTION OF SCIENCE.

…ited to 30 Members, of whom one-half at least must be foreigners.]

. Mar. 15	Adams, John Couch, LL.D., (Dub.) F.R.S. and Copley Medalist, V.P.R. Ast. S., F.C.P.S., etc., Director of the Observatory and Lowndsean Professor of Astronomy and Geology in the University of Cambridge. *Observatory, Cambridge.*
. Mar. 16	Berthelot, Marcelin Pierre Eugène. *Boulevard Saint-Michel,* 57, *Paris.*
. Mar. 16	Bertrand, Joseph. *Paris.*
. Mar. 16	Bunsen, Robert Wilhelm Eberard, Ph.D., For. Mem. R.S. *Heidelberg.*
. Mar. 16	Carus, J. Victor, Professor ot Comparative Anatomy. *Leipsic.*
. Mar. 15	Cayley, Arthur, LL.D.(Dub.), F.R.S., V.P. R. Ast. S., &c., Sadlerian Professor of Mathematics in the University of Cambridge. *Cambridge.*
. Mar. 16	Chasles, Michel, For. Mem. R.S. *Rue du Bac,* 62, *Paris.*
. Mar. 16	Clausius, Rudolph Julius Emmanuel, For. Mem. R.S. *Zurich.*
. Mar. 16	Cotta, Bernard von. *Freiburg.*

HONORARY MEMBERS—*Continued.*

SECTION OF SCIENCE—Continued.

Date of Election.	
1876. Mar. 16	Borchardt, Carl Wilhelm. *Berlin.*
1873. Mar. 15	Dana, James Dwight, LL.D., &c., Professor of Geology and Mineralogy. *Yale College, U. S., America.*
1866. Mar. 16	Darwin, Charles, F.R.S., &c. *Down, Beckenham, Kent.*
1869. Mar. 16	Daubrée, Prof. Gabriel Auguste. *Ecole des Mines, Paris.*
1876. Mar. 16	Decandolle, Alphonse, For. Mem. R.S., Professor of Botany. *Geneva.*
1863. Mar. 16	Dove, Heinrich Wilhelm, For. Mem. R.S. *Berlin.*
1841. Mar. 16	Dumas, Jean Baptiste, For. Mem. R.S., G.C.L.H., Secrétaire perpétuel de l'Institut de France. *Rue St. Dominique, 69, Paris.*
1875. Mar. 16	Gray, Asa, Professor of Botany, Harvard University. *Cambridge, Massachusetts, U. S., America.*
1876. Mar. 16	Haeckel, Ernst, Professor of Zoology. *Jena.*
1864. Mar. 16	Helmholtz, Hermann Louis, For. Mem., R.S. *Heidelberg.*
1873. Mar. 15	Hofmann, August. Wilhelm, Professor of Chemistry in the University. *Berlin.*
1874. Mar. 16	Huxley, Thomas Henry, M.D., LL.D., Fellow and Secretary of the Royal Society. *London.*
1864. Mar. 16	Hyrtl, Carl Joseph, For. Mem. R.S *Vienna.*
1874. Mar. 16	Lamont, Johann Von, For. Mem. R.S. *Munich.*
1878. Mar. 16	Pasteur, Louis. *Paris.*
1873. Mar. 15	Schimper, Wilhelm Philipp, Professor of Geology in the University. *Strasburg.*
1869. Mar. 16	Séquard, Charles Edouard Browne-, M.D., F.R.C.P., F.R.S. *Rue Gay-Lussac, 28, Paris.*
1873. Mar. 15	Stokes, George Gabriel, D.C.L., LL.D. (Dub.), Fellow and Secretary of the R.S., F.C.P.S., F.R.S.Ed., &c., Lucasian Professor of Mathematics in the University of Cambridge. *Lensfield Cottage, Cambridge.*
1878. Mar. 16	Thomson, Sir William, LL.D., D.C.L. *The College, Glasgow.*
1867. Mar. 16	Würtz, Adolph Charles, For. Mem. R.S. *Rue St. Guillaume, 27, Paris.*

(*One vacancy.*)

SECTION OF POLITE LITERATURE & ANTIQUITIES.

[Limited to 30 Members, of whom one-half at least must be foreigners.]

Elected in the Department of Polite Literature.

Date of Election.	
1869. Mar. 16	Gayangos y Arce, Don Pascual de. *London.*
1869. Mar. 16	Lassen, Christian, Ph.D. *Bonn.*
1849. Nov. 30	Lepsius, Karl Richard. *Berlin.*
1869. Mar. 16	Mommsen, Dr. Theodore. *Berlin.*
1863. Mar. 16	Müller, Professor Max. *Oxford.*

Elected in the Department of Antiquities.

1869. Mar. 16	Benavides, Don Antonio. *Madrid.*
1848. Nov. 30	Botta, Paul Emile. *Paris.*
1867. Mar. 16	De Rossi, Commendatore Giovanni Battista. *Rome.*
1863. Mar. 16	Keller, Ferdinand. *Zurich.*
1869. Mar. 16	*Larcom, Right Hon. Sir Thomas A., Bart., Major-General, K.C.B., F.R.S., &c. *Heathfield, Fareham, Hants.*
1854. Mar. 16	Mauray, Alfred. *Paris.*
1866. Mar. 16	Nillssen, Rev. S. *Copenhagen.*
1841. Mar. 16	Phillipps, (*late* Halliwell,) James Orchard, Esq., F.R.S., F.S.A. Lond. and Edin., &c. *Hollingbury Copse, Brighton.*
1867. Mar. 16	Visconti, Barone Commendatore P. E. *Rome.*
1867. Mar. 16	Worsaae, Prof. Hans Jacob Asmussen. *Copenhagen.*

Elected since the union of the two classes of Honorary Members in this Section.

1878. Mar. 16	Bradshaw, Henry, Fellow, King's College, Cambridge. *Cambridge.*
1876. Mar. 16	Carlyle, Thomas. *Chelsea, London.*
1878. Mar. 16	Curtius, Georg. *Leipsic.*
1875. Mar. 16	Franks, Augustus Wollaston, M.A., F.R.S., F.S.A. 103, *Victoria-street, London, S.W.*
1875. Mar. 16	Hardy, Sir Thomas Duffus, D.C.L., Deputy-Keeper of the Public Records, England. 35, *North-Bank, Regent's-Park, London, N.W.*
1878. Mar. 16	Kern, H. *Leyden.*
1873. Mar. 15	Longfellow, Henry Wadsworth. *Cambridge, Mass., U. S., America.*
1878. Mar. 16	Newton, Charles, F.S.A. *London.*
1873. Mar. 15	Nigra, His Excellency Cavaliere Constantino, Italian Minister to France. *Paris.*
1876. Mar. 16	Stokes, Margaret. *Carrig-Breac, Howth, Co. Dublin.*
1876. Mar. 16	Stubbs, Rev. William, M.A. *Oxford.*
1876. Mar. 16	Viollet-le-Duc, Eugene Emanuel. *Paris.*
1873. Mar. 15	Westwood, John Obadiah, Esq., F.S.A. *Oxford.*
1875. Mar. 16	Whitney, William Dwight. *Yale College, Connecticut, U.S., America.*
1876. Mar. 16	Windisch, Ernst. 3, *Neue Kirchgasse, Strasburg.*

SUMMARY.

Life Members	...	...	...	**189**
Annual Members	...	...	...	**182**
				371
Honorary Members (59 + 4) ...			...	63
		Total,	...	434

MONDAY EVENING, APRIL 14, 1879.

SIR ROBERT KANE, F.R.S., &c., President, in the Chair.

Thomas Dunbar Ingram, LL.B., was elected a Member.

Rev. Samuel Haughton, M.D., &c., read a Paper "On an Easy Method of obtaining the complete Differential Equations of Motion of an Ocean surrounding a Solid Nucleus, and subject to any Disturbing Forces (the Nucleus itself revolving on a Fixed Axis), without calculation or transformation of Co-ordinates, from simple Geometrical and Mechanical Principles." [Vide *Proceedings*, Vol. iii., New Series, Science, Part 3.]

The Secretary of the Council having brought down the several Reports of Council intended for the consideration of the Academy, and of which copies had been previously forwarded to the Members—

It was Resolved:—

"That for the accommodation of President Sullivan, Ph.D., the Report 'On the State of the Publication of the Táin Bó Cuailnge' be taken first."

ON THE STATE OF THE PUBLICATION OF THE TÁIN BÓ CUAILNGE.

This Report was read as follows by the Secretary of the Council, who moved its adoption:—

On 25th October, 1873, the following Minute is recorded in the Minute-book of the Committee:—

"Dr. Sullivan reported that he was prepared to proceed with the publication of the Táin Bó Cuailnge, text and translation, as a commencement of the series of Irish Historic Tales."

Upon this the Committee passed a Resolution requesting Dr. Sullivan—

"To proceed with the work, and, as soon as possible, to submit to the Committee a specimen of the style in which he would propose to have the printing executed, it being understood that the size shall be uniform with that of the Irish Manuscript series."

There is no Minute on the books of the Committee purporting that Dr. Sullivan ever complied with the above Resolution, by submitting to the Committee a specimen of the style in which he would have the printing executed, nor has any part whatever of the work ever been seen by the Committee.

Nothing appears in the Minute-book of this Committee with ref-
rence to the estimates for the work, but on the Minute-book of th
Publication Committee, under date December 1st, 1873, is recorded
Resolution accepting the estimate of Messrs. Browne & Nolan, o
certain conditions of type, &c.

The Report of Council for the year, read March 14th, 1874, con-
tains the following passage bearing on the publication of this work:-

"An edition of some of the most interesting ancient Irish Histori
Tales, with translation, has been commenced, and will be publishe
uniformly with the Irish MSS. series. The first of the tales, th
Táin Bó Cuailnge, will appear, it is hoped, in the course of th
present year. It will be edited by Dr. Sullivan, and the translatio
will be the joint work of that gentleman and Mr. O'Looney."

There seems to have been a general understanding that Profess
O'Looney would aid Dr. Sullivan, but the Committee have no recor
on their books of any communication whatever having passed betwe
them and Mr. O'Looney on the subject of this work until the presen
year.

In the beginning of the year 1876 the Council felt it to be desira
ble to endeavour to obtain some satisfactory account of the progress o
this work, which the report of March, 1874, had announced as in pre-
paration, with the hope that it would appear in the year 1874-5, an
accordingly, on March 11th, 1876, a Resolution was passed—

"That Dr. Sullivan be requested to furnish a Report on the exten
and progress of the printing of the volume of Táin Bó Cuailnge
entrusted to him to edit, and that he be requested to furnish copies o
all the sheets as printed."

At the time when this request was made, Dr. Sullivan seems t
have interpreted the request of the Council for information as a desir
on their part to subject his work to criticism, and accordingly replie
as follows:—

"Queen's College, Cork,
"*23rd March*, 1876.

"My dear Dr. Ingram,

"Excuse me for not having answered your letter about the Táin
Bó Cuailnge ere this. I could not do so sooner, and therefore not in
time for your Report, as I had to make some inquiries as to the amount
of matter set up in type, the state of the 'copy' of the text for the

printer, and many other matters which took some time. Much time was spent in settling the text to be followed, and the form in which the book should be printed, the extent to which the various readings of the manuscript should be given, and whether as Foot-notes or Appendix, as well as the extent and mode of giving explanatory notes, and lastly as to the collation of the text with the original.

"All these matters having been settled, a good deal of the text and translation was put in type. Some months ago, however, the work was suspended, in order to enable Mr. O'Looney to give his undivided attention to the preparation of the introduction to Leabhar Breac, which required an amount of work very disproportionate to its extent or appearance. Mr. O'Looney is now free to take up the Táin again, and we hope to be able to finish it before anything else shall interrupt us.

"There is one point referred to in your note about which there must be some mistake. I do not think it is usual for an author or editor to submit his work piecemeal to criticism, or to allow sheets of an unfinished work to be circulated about. When I undertook, in conjunction with Mr. O'Looney, to bring out a translation and text of the Táin Bó Cuailnge, I certainly did not understand that one of the conditions should be that I was to furnish copies of the sheets to anyone until the work was finished.

"Once the Academy had ordered the printing, and settled the general form of the work, it appears to me that their responsibility was only of the same kind as that which it undertakes in publishing Papers in its Proceedings.

"I am sure the Council must have inadvertently made the request communicated in your note, and which, so far as my experience goes, is without precedent.

"I remain,

"Yours very sincerely,

(Signed) "WILLIAM K. SULLIVAN.

"JOHN K. INGRAM, Esq., LL. D.,

"*Secretary of Council, R. I. A.*"

In reply, the Secretary of Council forwarded the following letter:

"*4th of April*, 1876.

"MY DEAR DR. SULLIVAN,

"Your letter of March 23rd having been before the Council at i
meeting yesterday, I was directed to inform you that the object of th
Council (in passing the Resolution communicated to you) was not t
ascertain how the work has been done, but what the work hither
done actually is, and how much remains to be done, and to ascertai
what funds will be required to meet the cost of this work.

"The Council still desire this information.

"I am, your faithful Servant,

"(for J. K. INGRAM, *Sec. of Council*),

"J. R. GARSTIN.

"W. K. SULLIVAN, Esq., Ph.D., M.R.I.A.,
"*President, Q.C., Cork.*"

To this letter of the Council no answer was sent.

By Dr. Sullivan's letter of 23rd March, however, the assurance wa given that the work would proceed, and the hope was held out that i would be finished before long. No record is made on the Minutes o anything having occurred which was likely to retard the work, and n complaint or suggestion on any matter bearing directly or indirectly o the work was ever made to the Committee or Council. As, however even after the letter of the Secretary of Council, no account of it progress was communicated by Dr. Sullivan to the Committee, the passed this Resolution on November 25, 1876:—

"That the Secretary of this Committee be requested to communicat with Dr. Sullivan, President, Queen's College, in order to ascertai the number of pages now printed of the Táin Bó Cuailnge, and th probable number remaining to complete the work; also the approxi mate amount of the expense already incurred for printing, explainin to Dr. Sullivan that the present financial position of the Academy makes it necessary that the Committee should be supplied with the information as soon as possible."

A copy of the above Resolution having been forwarded to Dr. Sullivan, on 29th December, 1876, Dr. Sullivan replied to the Secretary as follows:—

"QUEEN'S COLLEGE, CORK,
"29*th Dec.*, 1876.

"DEAR SIR,

"I am now in a position to give the Committee of Irish MSS. the information you asked for in your letter of the 27th November.

"The original estimate of Messrs. Browne & Nolan (which is in the Academy) was for text and translation on opposite pages, making about thirty-two sheets, or 512 pages, of which 500 copies were to be printed. Preface, notes and index not estimated for. Including these, the book will make about 700 pages, or forty-four sheets.

"The text is all copied out and ready for printers. The translation is almost all revised, and the greater part of the notes (which will form an Appendix, and not be printed as foot-notes) are also ready: in fact nearly all the work is now done, and it can be passed through the press very rapidly.

"Six sheets of text and translation are ready to be printed off. A good deal of time was spent in preliminary arrangements, so as to save expense in correcting hereafter. This will enable us to carry the work more rapidly through the press henceforward.

"I remain, &c.,

"W. K. SULLIVAN.

"PROFESSOR ATKINSON."

From this letter the Committee naturally inferred that, all obstacles having been now removed, the work would proceed continuously and rapidly; and accordingly, on March 24th, 1877, the Treasurer was authorised to pay Messrs. Browne & Nolan on account of the work to the extent of the funds available for that purpose. On this occasion a sum of £95 was paid.

For a period of more than a year from the date of the above letter (29th December, 1876) nothing was heard from Dr. Sullivan as to the state of the work under his care, so that the Committee at length felt

bound to call on the editor for a report of its progress; and accordingl
on May 25th, 1878, they passed the following Resolution :—

"That the Secretary be requested to seek from Dr. Sullivan infor
mation as to the progress of the Táin Bó Cuailnge, referring to Dr. Sul
livan's letter of the 29th December, 1876."

This Resolution, on being forwarded to Dr. Sullivan, elicited from
him the following reply, read at the Committee Meeting of June 22nd
1878 :—

"*May*, 1878.

"Dear Sir,

"I have received your note of the 28th inst. (May) relative to th
Táin Bó Cuailnge, and have forwarded it to Professor O'Looney. S
soon as I hear from him I shall write again.

"I remain, &c.,

"W. K. Sullivan.

"Professor Atkinson."

As Dr. Sullivan, however, did not write again, the Committe
after waiting nine months, were forced to take action again in th
matter, and accordingly, on February 15th, 1879, it was Resolved :-

"That Dr. Sullivan be requested to give the Committee the infor
mation respecting the progress of the Táin Bó Cuailnge, which h
has never furnished since it was applied for by the Committee in May
1878 ; and, in particular, to state what portion of the work is in type
how much of it has been printed off, and when it is likely to be com
pleted ; and

"That in communicating this Resolution, the Secretary be directe
to request that Dr. Sullivan will furnish the desired information i
time to be laid before them at their next Meeting, on February 22nd.

In reply to this Dr. Sullivan sent the following letter, which wa
placed upon the Minute-book of the Committee :—

"QUEEN'S COLLEGE, CORK,
"*20th February*, 1879.

"SIR—I have to acknowledge the receipt of your letter of the 15th instant, enclosing a copy of a Resolution of the Irish MSS. Committee of the Royal Irish Academy. This Resolution ignores altogether my answer to their former application, in which I stated that I would write to Professor O'Looney on the subject, and communicate with them when I heard from him. It seems to me to be necessary, therefore, to remind the Committee of my position in connexion with the subject of the above Resolution.

"Professor O'Looney laid before the Academy a translation of the whole Leabhar na h-Uidhri, and also translations of the Táin Bó Cuailnge, and several other Tales of the same cycle. Many members of the Academy, and others interested in Irish literature, expressed a wish that these translations, especially those of the Tales, should be printed. The Irish MSS. Committee of the time, fully impressed with the importance of providing scholars with such valuable help, proposed to make a beginning by printing the text and translation of Táin Bó Cuailnge. Being desirous of giving any help I could in this useful work, and having myself already printed the text, with a translation, of the principal episode of the Tale in question, I undertook to see Professor O'Looney's work through the press.

"The progress of the Book necessarily depended, so far as I was concerned, upon my getting proofs from the author. At first considerable progress was made; but Professor O'Looney, considering that he had been badly treated by the Academy, that is, I presume, by the Irish MSS. Committee, in respect of several matters, and if I understand him rightly, of this particular work among the number, refused to proceed with the Táin Bó Cuailnge until justice shall have been done him. I have always been ready and willing to perform what I undertook to do, and I am now just as anxious as ever to devote any time that may be necessary to see the Táin Bó Cuailnge through the press; but I decline any further responsibility in the matter. The Committee should apply for the information they seek to Professor O'Looney, who is on the spot, and who alone could give it. I am sure he will do so if asked; and if not, will be able to give a satisfactory reason for his refusal. No one ought to be as anxious, and, I believe,

no one could be more desirous than Professor O'Looney for the satisfa tory completion of the Táin Bó Cuailnge. His refusal to proceed wit it until the Academy shall have done him right shows, therefore, hi strong sense of the injustice done him, and it is but reasonable t assume that he must have good grounds of complaint. The Com mittee itself being the chief cause of delay—I hope only the involun tary cause—I trust they will at once remove the only obstacle t the completion of the Book—the injustice of which Mr. O'Looney complains.

"I am, Sir,

"Your obedient Servant,

(Signed) "William K. Sullivan.

"Robert Atkinson, Esq.,

"*Secretary of the Irish MSS. Committee, R.I.A.*"

The statements made in this letter, referring to injustice done t Professor O'Looney, are quite incomprehensible to the Committe who have always endeavoured to secure for him his full share credit for any work performed by him in the service of the Academy and from whom they had never heard any complaint of injustice don him by the Committee in any matter. In this matter they had ha no dealings with Professor O'Looney; the charge of proceeding wit the work had been entrusted by the Committee to Dr. Sullivan alone and on his own report that he was prepared to proceed with it.

[Prof. O'Looney could, if he thought proper, have consulted th Minute-book of this Committee, in which the letter of Dr. Sullivan was set out at length, and could have transcribed it if he had desired. The Secretary of the Committee, on being applied to verball for a copy, to be made by the officers of the Academy, informed Pro O'Looney that this application should be made in writing to the Com mittee, when there was not the slightest doubt that his request, thu regularly brought before them, would be immediately complied with This Prof. O'Looney did not do.]

To this letter the Committee felt there was but one reply, and ac cordingly, on February 22, 1879, they Resolved—

"That as Dr. Sullivan has by his letter of February 20, 1879 declined 'any further responsibility' in the matter of the publication o the Táin Bó Cuailnge, the arrangement entered into by the Resolu-

tion of October 25, 1873, requesting Dr. Sullivan 'to proceed with the work,' be regarded as having now fallen through."

As the Committee were, however, naturally anxious that the work undertaken should not be left unfinished, they further Resolved—

"That as it appears from the letter of Dr. Sullivan that he declines any further responsibility in the matter of the Táin Bó Cuailnge; and that further, he regards Prof. O'Looney as the 'author' of the publication in question, a letter be addressed to Prof. O'Looney requesting him to be good enough to inform this Committee whether he will undertake to carry on the printing of the work under the supervision of the Committee."

To this Resolution Prof. O'Looney replied that he was "prepared to proceed with the Táin on receiving particulars of the course which may be considered most satisfactory for carrying through the undertaking."

Prof. O'Looney having signified his assent to the proposal of the Committee on certain conditions, the Committee naturally desired to see what had been done, because as they had never had any opportunity of seeing a page of the work, they could not possibly lay down any course to be pursued with reference to the manner of its execution in the future.

They accordingly desired the printers, Messrs. Browne & Nolan, to furnish their account for the portion of the work printed off up to date, together with a clean copy of the work so far as printed, to be laid before this Committee at their next Meeting; and further, pending the settlement of the necessary arrangements, the Committee informed the printers that "the printing of the work was not to proceed further without an order from this Committee."

At the same Meeting they also passed a Resolution—"That a letter be written to Prof. O'Looney, annexing a copy of the above Resolution, and informing him that when the sheets, so far as at present printed, shall be before them, the Committee will be prepared to give him particulars of the course which, in their opinion, may be most suitable for carrying through the undertaking; and that it will be their desire to ascribe to Prof. O'Looney all the credit which they have learned is due to him in the preparation of the work, and to give him every facility in their power for completing it in a manner agreeable to himself and satisfactory to the Academy."

To this Resolution Prof. O'Looney has not replied.

Messrs. Browne & Nolan have not sent the sheets as directed by the Committee, who are thus prevented from furnishing particulars to Prof. O'Looney of the course they deem suitable in order to carry on the work. Annexed is a copy of a letter received from the printers, from which the Committee conclude that Messrs. Browne & Nolan decline to comply with the request of the Committee, until authorised by Dr. Sullivan and Prof. O'Looney:—

"Wholesale Paper Warehouse,
"24, Nassau-street,
"Dublin, 8*th March*, 1879.

"Sir,—In reply to your favour of the 3rd instant, we regret our inability to give any further information than that contained in our letter of 19th November, 1877, the printing work to which you refer being now in the same state as then. Dr. W. K. Sullivan and Professor O'Looney have not replied to our letters on the subject.

"Yours truly,
(Signed) "Browne & Nolan,
"*Per* P. M.

"Robert Atkinson, Esq."

Council has taken steps to define the Academy's legal position with Messrs. Browne & Nolan, by addressing the following letter to them:—

April 7, 1879.

"Sir,

"I am directed by the Council of the Royal Irish Academy to request that you deliver, without delay, at the Academy House, the amount of printed matter now in your hands, and prepared by you in pursuance of the contract contained in the letter of the Secretary of MSS. Committee to you, dated the 2nd day of December, 1873; and at the same time furnish your account for the work in pursuance of such contract hitherto done by you; the balance on which, together with expense of carriage, will be at once discharged by the Academy.

"If you decline this request, the Council would desire a statement from you, why, having received so large a payment from the

Academy, you refuse to recognize their property in the work done for them by you.

"An answer is requested from you before the next Meeting of Council, which will be held on Wednesday the 9th inst., at 4 o'clock, P.M. And in the event of no reply being received by that time from you, the Council must conclude that you decline to accede to this request.

"Your obedient Servant,

"ROBERT ATKINSON,

"*Secretary of Council.*

"Messrs. BROWNE & NOLAN."

To this letter no answer has been received. Council is advised that as the matter now stands, it is in the option of the Academy either to enforce the delivery of the work done, or to treat the behaviour of Messrs. Browne & Nolan as a rescission of the contract *ab initio,* and to have back again the money paid on account; and recommend that Council should be authorized to proceed in that matter as it may seem most for the advantage of the Academy, with power to take such legal proceedings as may be necessary in that behalf, and submits the foregoing as its Report.

Whereupon the following Amendment was proposed by Professor Hennessy, seconded by The O'Conor Don, M.P. :—

"That the Academy declines to authorize the Council to take legal proceedings with regard to the work done by Messrs. Browne & Nolan. And that a Special Committee of the Academy be appointed to investigate and report upon the matter at issue.

This Amendment, by vote of the Academy, was altered as follows:—

"That the Academy do appoint a Special Committee of the Academy to investigate and report upon the matter at issue."

A division was taken on the Amendment, which was declared lost; the original Motion was then put, and the President declared it adopted.

It was then Resolved :—

"That the Academy do adjourn specially till Friday evening, at its usual hour, to consider the remaining Reports."

SPECIAL MEETING.

FRIDAY EVENING, APRIL 18, 1879.

SIR ROBERT KANE, F.R.S., &c., President, in the Chair.

The consideration of the Reports of the Council was resumed. It was Resolved :—"To proceed with the Report on the Editorship of the Book of Leinster."

ON THE EDITORSHIP OF THE BOOK OF LEINSTER..

This Report was read as follows by the Secretary of Council, who moved its adoption :—

On the 14th December, 1872, a Resolution was passed by the Committee to the effect—

"That the President be requested to communicate to the Board of Trinity College, Dublin, that this Committee is prepared to undertake the production of a lithographic fac-simile of the Book of Leinster similar in style to Leabhar Breac and Leabhar na h-Uidhri."

This Resolution the Secretary was desired to communicate to the President, with a request that he would be good enough to take such steps as he might deem desirable in the matter, and to inform the Committee of the result.

At this same Meeting, prior to the passing of this Resolution, the Committee had had laid before them "A Descriptive Catalogue of the Contents of the Book of Leinster," by Mr. O'Looney, when the following Resolution was passed :—

"That when funds are available, the Treasurer be authorized to pay Mr. O'Looney for preparing a catalogue of the contents of the Book of Leinster such amount as shall be certified by the Secretary of the Academy and the Librarian."

The catalogue laid on the table by Mr. O'Looney was a necessary preliminary to any recommendation on the part of this Committee to the Board of Trinity College to co-operate in the undertaking of this work, as the descriptive catalogue of MSS. in Trinity College Library does not enter into any detail of the contents of that MS.

The catalogue should, by the terms of the Resolution, have become the property of the Academy, on payment of the sum duly certified.

The President of the Academy (Mr. Jellett) accordingly brought the matter before the Board of Trinity College on February 1st, 1873, and in a letter to the Secretary of Council (Dr. Ingram) signified the assent of the Board on certain conditions.

From this period till the 23rd May, 1874, the Committee was engaged in settling the details necessary to enable the work to be efficiently performed, as will appear from the following Resolutions.

On the 17th May, 1873, it was Resolved by the Committee—

"That the President be requested to name a day during the following week on which he could meet and confer with this Committee as to the details in connexion with the purchase of the paper and lithography of the Book of Leinster, and the other arrangements for that work."

Accordingly, on the 21st May, 1873, Mr. Jellett presided at a Meeting of this Committee, when the details in connexion with the publication of the Book of Leinster were considered.

On the 14th June, 1873, a further Resolution was passed by this Committee, to recommend Council to request the President to bring under the notice of the authorities of T. C. D. certain considerations which made it expedient that, for the purpose of transcription, the MS. should be deposited in the Academy House.

On 25th October, 1873, the President reported to this Committee that the Board of T. C. D. had consented to deposit the Book of Leinster in the Academy House in portions; and also that the Board had agreed to purchase in advance all the paper required for the work.

On the same day the President was requested to take the requisite steps to obtain permission for Mr. O'Longan and Mr. O'Looney to have access to the Book of Leinster for the purpose of putting the leaves in sequence, preparatory to commencing the copy.

On 24th January, 1874, the Committee having considered the estimates for the paper and the printing of the Book of Leinster, adjourned till January 26th, when it was Resolved—

"That a Sub-committee, consisting of the Treasurer, the Secretary of the Academy, the Secretary of Council, and the Librarian, be requested to examine and arrange all matters in connexion with the purchase of the paper and the lithography of the Book of Leinster."

On 23rd May, 1874, it was Resolved by the Committee—

"That the sample of paper from Messrs. Pim, recommended by

them, and now marked by the Chairman, be approved of for the Bo
of Leinster."

Matters having been thus finally arranged, the Committee on t
same day passed this further Resolution—

"That the Librarian be requested to have the goodness to und
take the supervision through the press of the Book of Leinster, and
arrange all details in connexion with it on behalf of the Co
mittee."

This duty Mr. Gilbert continued to fulfil until the close of t
year; (he was present for the last time at the Meeting of 26th
December, 1874;) but the state of his health soon after obliged hi
to withdraw from his Academy duties. Towards the end of th
Academic Session of 1875–1876, when Mr. Gilbert, by his prolong
absence, was about to become ineligible for re-election to his seat
the Council, owing to non-attendance, the Council in February, 187
passed a Resolution to advise the Academy to waive the by-law whi
made him ineligible for non-attendance. As Mr. Gilbert's adviser
however, declined to avail themselves of the offer, the matter pr
ceeded no further, and Mr. Gilbert being thus no longer re-eligibl
Dr. Atkinson was, at the Stated Meeting of March, 1876, elected b
the Academy Librarian in his stead.

As from the date of his last attendance at this Committee, o
December 26th, 1874, up till this period of March, 1876, no comm
nication had been received from Mr. Gilbert, and the work of tra
scription of the Book of Leinster had remained entirely without an
other supervision than that exercised by members of this Committe
the Committee, feeling the necessity of some responsible personal supe
intendence over the work, passed a Resolution on April 22nd, 1876:-

"That the Librarian be requested to supervise the publication
the Book of Leinster in its passage through the press; and, on th
completion of the work, to prepare such prefatory matter as may see
to him suitable as an introduction to the work."

By this Resolution, Dr. Atkinson, designated under his then offici
title as Librarian, was instructed to prepare an introduction to th
work on its completion, without any special direction as to the natu
or contents of such preface.

The following extract from the proceedings of the Academy, take
from a Paper of Professor O'Looney, read January 13th, 1873, "On th

Book of Leinster," points naturally to the source whence information ought to have been available :—

"The want of a descriptive catalogue of the contents of so important a book as that of Leinster has long been felt, and to supply this, I have now the honour to submit one in which I have endeavoured to specify every piece to be found in the MS., noting in all instances the page, column, and line where the composition commences, and giving the title or first line of each piece."

This Paper, it will be observed, was read before the Academy prior to the acceptance by the Board of Trinity College of the proposal to lithograph the Book of Leinster.

The work, at the time of Dr. Atkinson's appointment, had advanced during the few months of Mr. Gilbert's supervision, and during his prolonged absence, as far as page 192 of the fac-simile.

Mr. Gilbert's state of health having permitted him to resume his occupations, and the year during which he remained ineligible under the by-law having expired, his name was replaced on the list of eligibles for Council, and on his re-election as a member of Council on the 16th March, 1878, Dr. Atkinson voluntarily resigned the Librarianship in order that Mr. Gilbert might be, as he was, re-elected to that office. Dr. Atkinson did not, however, regard himself as freed from the duties imposed on him by the Resolution of 22nd April, 1876, and continued to supervise and conduct the preparation of the Book of Leinster for the press, as from the date of his appointment to that duty, with the full concurrence of the Committee.

Towards the end of last year, however, when the work of transcription was nearly completed, and there remained the important task of preparing the introduction, Mr. Gilbert, alleging that, as Librarian, he was the proper person to discharge the duty of supervising the Book of Leinster, under the terms of the Resolution of 22nd April, 1876, demanded of Dr. Atkinson that he should withdraw from the performance of that duty. There had been several Meetings of the Committee during the year, at which Mr. Gilbert had been present, in one of which an important matter bearing on the Book of Leinster had been considered without any objection being made by Mr. Gilbert to the action of Dr. Atkinson in supervising the work.

Upon learning from Mr. Gilbert for the first time that he considered himself wronged in the matter, Dr. Atkinson at once brought this state of facts under the notice of Council at their next Meeting,

Dec. 2nd, 1878, declaring his willingness to withdraw if it were deci that he had been entrusted with the duty merely in his capacity Librarian; but, otherwise, expressing his desire to continue and co plete the work with which he had been charged by the Resolution the Committee. Council on that occasion directed that a Report sho be made of all the Resolutions passed in reference to the editorship the Book of Leinster. This Report was accordingly prepared and p sented at the Meeting of 20th January, 1879, to the Council, w decided that it should be referred to this Committee, as involving matter primarily within their jurisdiction. Accordingly, in pursuan of this reference, the Committee took the Report into their con deration, and passed the following Resolution :—

"That, by their Resolution of the 22nd April, 1876, this Committ appointed Dr. Atkinson, therein described by his then official design tion of Librarian, to supervise the publication of the Book of Leinst in its passage through the press, and, on the completion of the wor to prepare such prefatory matter as might seem to him suitable as introduction to the work;

"That such duty was entrusted to him on the ground of his pe sonal fitness to discharge it, and not in his official character as Libr rian for the time being; and

"That the Committee therefore consider that Dr. Atkinson con tinues to be still charged with the duties so entrusted to him."

Mr. Gilbert has not, however, accepted their construction of the own Resolution, and does not withdraw his claims.

Dr. Atkinson, being thus authoritatively recognised as the respon sible editor, then took steps to prepare his introduction to the worl and accordingly, as was natural, applied to Professor O'Looney to b furnished with the catalogue referred to in the Minutes of the 14t December, 1872, and which had been submitted by him to the Academ in the year 1873, and which, therefore, should have been in th possession of the Academy. Professor O'Looney, who had, up to th time, Dr. Atkinson informs the Committee, worked harmonious under his supervision, declined to furnish the catalogue. On th refusal being made known to the Committee, they passed a Resoluti on 15th February, 1879 :—

"That, observing in the minutes that a descriptive catalogue the Book of Leinster by Professor O'Looney was laid before the Com mittee on the 14th December, 1872, Professor O'Looney be requeste

to send in now that catalogue to the Committee, and also to furnish the certificate of Dr. Sullivan and Mr. Gilbert as to the amount payable for it; and that a copy of this Resolution (together with a copy of the Minute above referred to, and the Resolution thereon) be communicated to Professor O'Looney, with a request that he will be good enough to let the Committee have his answer before or at its Meeting on the 22nd February."

To this request of the Committee Professor O'Looney refused to accede, in a letter of 22nd February, in which he alleged as follows:—

"Having prepared the present work to accompany the Academy's edition of the Book of Leinster, I submitted it to the Irish MSS. Committee, and it was approved by the Committee at its Meeting on the 14th December, 1872, as appears from the Minutes and Resolutions of the Committee. I now only await the requisite order to put it to press as on the former occasions.

"With reference to the certificates for payment which your Committee asks me to send in, there will be no difficulty when the work is in print."

The Committee, finding no such acceptance of an introduction in their Minutes, and recognising the impropriety of incurring expenses in printing a document that had never been submitted to the inspection of the responsible editor, and of the nature, extent, and execution of which he had consequently no means of judging, informed Professor O'Looney that if the catalogue, as prepared by him, were not furnished by a given day, Dr. Atkinson would be requested to proceed with the work with such materials as are at his command.

The time fixed having expired, and the catalogue not having been brought in by Professor O'Looney, Dr. Atkinson, in pursuance of the direction of the Committee, began his preparation of the introduction without the assistance of Professor O'Looney's catalogue. In order to facilitate the performance of this lengthy task, Dr. Atkinson gave certain directions to the Academy's scribe, Mr. O'Longan, whereupon Mr. Gilbert personally interposed, and told Mr. O'Longan that, in his opinion, Dr. Atkinson had no right to interfere. On this interposition being reported to the Council, Mr. Gilbert made a statement at the Council table that he was himself now engaged in printing an introduction to the publication. If this preface be either the document prepared by Professor O'Looney or founded upon it, as Professor O'Looney, in his letter of 22nd February, explicitly asked leave from

this Committee to put his catalogue to the press as an introduction the work, the Committee do not undertake to explain this stateme of Mr. Gilbert of his wholly unauthorized printing of such prefato matter.

The Committee having, on the application of Dr. Atkinson, auth rized Mr. O'Longan to transcribe the headings of the several trac and articles in the Book of Leinster, that work is being proceeded wi by Mr. O'Longan, without further interference from Mr. Gilbert.

The entire work is now lithographed, though not finally revised. contains 401 pages, of which upwards of 200 have been carried on und the supervision of Dr. Atkinson, while the preceding pages, fro 74–193, were, owing to the absence of Mr. Gilbert, and the reluctan of the Committee to take any action so long as there remained an hope of Mr. Gilbert's being able to resume his duties, left witho any direct responsible supervision.

Council has directed that it be intimated to the Academy's printe that no printing in connexion with the Book of Leinster will be regarde as done on the credit of the Academy unless sanctioned by the MS Committee.

Whereupon the following Amendment was proposed by D Hayden, and seconded by Dr. Madden:—

"That the Academy consider it desirable that all the arrang ments requisite to complete the publication of the Book of Leinste including the Introduction and preliminary matter, shall continue t be entrusted to the present Librarian of the Academy, under whos supervision the undertaking was commenced; that the Council b requested to afford him all requisite facilities within their power fo the satisfactory execution of the work, and that the Report no presented to the Academy be referred back to the Council for re consideration in the foregoing respects."

A division was taken, and it appeared that there were 56 vote against the Amendment, and 26 votes for it.

The President having declared the Amendment lost, the origin Motion for the adoption of the Report was put, and declared carried.

ON THE PAYMENT TO THE EDITOR.

The Secretary of the Council then read Report on the Payment t the Editor of the Academy's Transactions and Proceedings as follow and moved its adoption:—

At a Meeting of the Council, held on June 17, 1878, it was moved by Dr. Atkinson, seconded by Mr. Gilbert, and Resolved—"That the Council considers it expedient to engage the services of a paid Editor, for a sum not exceeding £40 yearly, with a view to securing the prompt publication of the Papers read in the Academy, and that the Publication Committee be requested to give effect to this Resolution."

Accordingly, the Committee of Publication having considered this reference from Council, on June 20th, passed a Resolution:—

"That the Secretary be requested to communicate with Dr. Wright, informing him that a sum of £40 per annum had been allocated for editorial purposes, and to ask him if he will undertake, at that rate, under the general direction of the Publication Committee, the editing of the Proceedings and Transactions, so as to secure a regular and prompt issue of the same."

Dr. Wright having, in a letter of the 25th June, signified his "willingness to do what he could to assist the Publication Committee to edit the Transactions and Proceedings," the Committee, on the 25th June, Resolved—"That Dr. Wright be appointed for one year Editor of the Proceedings and Transactions, in conformity with the terms of the Resolution of this Committee of 20th June, 1878." Adopted by Council, April 9, 1879.

The Report was put, and declared adopted.

On the Cunningham Fund Scheme.

The following Report on the Cunningham Fund Scheme having been taken as read, Dr. Atkinson moved its adoption:—

Council now lays before the Academy the Scheme approved of by the Master of the Rolls for the Administration of the Cunningham Fund, which, owing to the illness of an officer of the Court, was not certified in time for the Stated Meeting, and recommends, by Resolution of March 17th, 1879—

"That the Scheme, as finally settled and authenticated, be printed, and communicated to the Academy, on behalf of the Council, by the Secretary of Council, who shall also lay on the table the documents received from Messrs. Ellis and Barlow; and that the Academy be commended to authorise the President and Treasurer to attach the al of the Academy to the transfer of such a portion of the Government Stock as may be required to pay the costs, when taxed."

IN THE HIGH COURT OF JUSTICE IN IRELAND,
Chancery Division.

MASTER OF THE ROLLS.

In the Matter of the Royal Irish Academy, and in th Matter of the 52nd Geo. 3, c. 101, intituled "An Ac to provide a Summary Remedy in case of Abuse o Trusts created for Charitable Purposes."

SCHEME for the regulation and management of the bequest of on thousand pounds made by the will of TIMOTHY CUNNINGHAM formerly of Gray's Inn, in the county of Middlesex, dated tent June, one thousand seven hundred and eighty-nine, to th ROYAL IRISH ACADEMY, for the purpose of being disposed of i such premiums as the said Academy should think proper, fo the improvement of natural knowledge, and other objects o their Institution, and of the stocks and funds now representin such bequest.

The said bequest, with the interest and dividends which hav from time to time been added thereto, amounting to the sum of tw thousand six hundred and eighteen pounds, nine shillings, and fiv pence, Government new Three per cent. Stock, now standing in th books of the Governor and Company of the Bank of Ireland, in th name of the ROYAL IRISH ACADEMY, after payment thereout of th costs of the proceedings in this Matter, and order herein, shall hence forward constitute and be called "The Cunningham Bequest Fund."

The Annual Income of said fund shall be applied as follows :—

1st. In premiums of an honorary character, such as medals an other marks of distinction of a like nature, to be awarded, from tim to time, by the Council, for the time being, of the ROYAL IRIS ACADEMY, to persons rendering eminent services in the improvemen of knowledge in Science, Polite Literature, or Antiquities.

2nd. In pecuniary premiums to be awarded, from time to time, b said Council to the authors of the best Essays (by said Council con sidered worthy of such premiums) upon subjects connected wit Science, Polite Literature, or Antiquities, such subjects to be propose by said Council, when and in such manner as they shall think fit.

3rd. In the publication, under the title of "CUNNINGHAM PRI MEMOIRS," of such Papers in Science, Polite Literature, or Antiquitie

communicated to the Academy as, in the opinion of the said Council, may possess eminent merit.

4th. If, after providing for the several purposes aforesaid, any balance of said annual income shall remain undisposed of, same shall be applied for the purpose of increasing future pecuniary premiums, to be awarded under clause two, as the said Council shall think most expedient.

Dated this 16th day of December, 1878.

EDWARD SULLIVAN, M.R.

Filed 11th of March, 1879.

The following Amendment was moved by Professor Hennessy, and seconded by Dr. Madden :—

"That while the Meeting agrees to the payment of the law costs from the Cunningham Bequest Fund, we express our regret that this reduction of the Fund was not avoided by the adoption by the Council of the strongly expressed opinion of many Members of the Academy, that there should be no deviation from the testator's will."

The Amendment having been declared lost, the original motion was put, and carried.

ON THE FELIRE OF OENGUS.

The following Report on the Felire of Oengus having been taken as read, its adoption was moved by Dr. Atkinson :—

At a meeting of the Publication Committee, on March 27, 1872, at which were present Mr. Gilbert, Mr. Garstin, and Dr. Sullivan, the sum of £51 5*s.* was paid to Mr. Thom on account of the printing of the Felire. No further sum has ever been expended on this work from the funds at the disposal of this Committee, as, in the following and succeeding years, the additional grant of £200 a-year in aid of the publication of Irish MSS. enabled the Committee of Irish MSS. to carry on the printing of the work, without aid from the ordinary publishing funds of the Academy.

In a letter from the Government, dated December 22, 1875, it was especially ordered that the whole grant-in-aid of £200 a-year should be "strictly appropriated to the cost of publishing the Leabhar Breac, the Book of Leinster, and the Felire of Oengus."

Since the date of that first payment by this Committee, on March 27, 1872, sums amounting to £200 have been expended on the printing

of the Felire, *i. e.*, an average of £33 yearly. None of this expen has been borne by the Publication Committee, who have, during th interval, expended the sum of £2070 on the publication of Papers re before the Academy, being an average of £345 yearly.

Adopted by Council, April 9, 1879.

The following Amendment was moved by Mr. Gilbert, and second by Dr. Hayden :—

"That the Report on the Felire of Oengus be referred back t Council, with a request that they will be good enough to state ho much of the grant voted by the House of Commons has been expende on this work for alterations, &c."

The Amendment having been declared lost, the original Motio was put, and carried.

On the Academy's Todd Professorship.

The following Report on the Academy's Todd Professorship of th Celtic Languages having been taken as read, its adoption was move by Dr. Atkinson :—

Council has received the following communication from the Com mittee appointed by the subscribers to the "Todd Memorial Fund" to carry out the resolution of the subscribers, that the Memorial shal take the form of such Professorship in connexion with the Roya Irish Academy :—

"Royal Irish Academy,
"19, Dawson-street, Dublin,
"*April* 7, 1879.

"Sir,

"In compliance with the request made by the Council of th Royal Irish Academy, on the 17th of March last, to be furnished wit a statement showing the amount and position of the Todd Memoria Fund, we beg to forward herewith the Report of the Committe on the subject, together with copies of the documents referred t therein.

"We are, Sir, your obedient Servants,

"John K. Ingram,
"John Ribton Garstin, } *Secretaries, Todd Nationa Memorial Committee.*

"Robert Atkinson, Esq., LL. D.,
"*Secretary of the Council of the*
"*Royal Irish Academy.*"

REPORT ENCLOSED.

This Committee was appointed at a general meeting of the sub-cribers to the Todd Memorial Fund, held on the 27th of October, 869, for the purpose of carrying into effect the resolution of the sub-cribers that such Memorial should take the form of a Professorship of he Celtic Languages, to be founded in connexion with the Royal rish Academy. The Committee appointed Mr. J. T. Gilbert, who is member of the Council of the Royal Irish Academy, and Mr. Iardinge, joint treasurers of the fund. A proposal having been made y Mr. Gilbert and others to apply the fund to a different purpose, and he Council of the Academy having protested against that course, unless rith the sanction of a public meeting of the subscribers, and saving he rights of the Academy, and Mr. Hardinge having died, a requisi-ion was, on the 27th of January, 1879, addressed to the Secretaries of his Committee to convene such meeting for the purpose of appointing a oint treasurer with Mr. Gilbert, and for the transaction of general usiness. The Secretaries, in the exercise of their discretion, on the 0th of February last convened a Meeting of this Committee for those urposes, to be held on the 21st of February ensuing. On the 17th of he same month, the Council of the Academy, by Resolution of that ate, declared its willingness to advise the Academy to accept the trust or founding such Professorship.

Mr. Gilbert, without the knowledge or consent of the Committee, odged, on the 21st of February, 1879, the Trust Fund, so vested in im as such surviving treasurer, in the Court of Chancery, under the rovisions of the Trustees Relief Act, 11 & 12 Vict. c. 68.

The reasons which induced Mr. Gilbert to make such lodgment re stated by him, in an affidavit dated February 15th, 1879, in sup-ort of his petition to lodge, to be, that the fund is wholly insufficient endow and support the proposed Professorship, and that differences opinion would appear to exist as to the best disposition of the fund; ad further that there does not now appear to be any power to appoint new trustee in the place of Mr. Hardinge, deceased.

The Committee do not admit that the fund is insufficient, but, on e contrary, trust that, with the co-operation of the Academy, a Pro-ssorship may be established on that foundation. They abstain from marking on the statements as to differences of opinion or alternative

projects, conceiving the consideration of such topics to be premat[ure] until the feasibility of the object determined on by the subscri[bers] shall have been practically tested.

At the meeting of this Committee, held on the 21st of Febru[ary,] 1879, the Rev. M. H. Close was appointed joint treasurer with [Mr.] Gilbert, in the room of the late Mr. Hardinge.

The funds so brought in appear, by the annexed schedule, to c[on]sist of £1209 18*s.* 4*d.* Government Three per cent. Stock, [and] £12 0*s.* 4*d.* cash, and there remains a sum of £107 12*s.* 8*d.* Gove[rn]ment Three per cent. Stock, representing £100 cash, standing in [the] names of Mr. Gilbert and Rev. M. H. Close, contingently applicabl[e to] the trust if a like sum of £100 shall be subscribed, or if the conting[ent] donor shall so direct.

We beg herewith to transmit—

"(**a**.) A copy of the Resolution of the Council of the Royal Iri[sh] Academy of January 20th, 1879;

"(**b**.) A copy of the Circular referred to in Mr. Gilbert's Affidavi[t;]

"(**c**.) A Printed Letter referred to in same;

"(**d**) A copy of the Advertisement of 10th February, 1879, co[n]vening Meeting of Committee;

"(**e**.) A copy of the Resolution of the Council of the Royal Iri[sh] Academy, of February 17th, 1879;

"(**f**.) A copy of the Affidavit of Mr. Gilbert of the 15th Februar[y,] 1879;

"(**g**.) A copy of the Notice of Lodgment received by Rev. M. [H.] Close from Mr. Gilbert's solicitor in the matter;

"(**h**.) A Statement of Accounts."

Council recommends that it be empowered to take such steps in a[nd] about drawing said fund out of Court as may be necessary, and submi[ts] the foregoing as its Report.

[a.]

RESOLVED—

"That the Royal Irish Academy having an interest in the Todd Memorial Fund, the Council reserving all rights of the Academy, protests against any allocation of the Fund, other than that already approved by the Subscribers, without the consent of the said Subscribers in public meeting assembled being first obtained."

[b.]

"ROYAL IRISH ACADEMY,
"19, DAWSON-STREET, DUBLIN,
"*November*, 1878.

"*Memorial to the late* J. H. TODD, D. D.

"SIR,

"More than eight years have elapsed since, on my proposition, a subscription was opened for a Memorial to commemorate the services rendered by the late Dr. Todd towards the promotion of the scientific study of the ancient historic and linguistic monuments of Ireland.

"It was hoped that sufficient funds might be received to endow a Professorship of Celtic Languages in connexion with the Royal Irish Academy, and thus advance the accurate knowledge of ancient Irish Literature, and further the publication of our historical manuscripts.

"The total fund received—with the interest to the present time superadded—amounts to about £1000—a sum totally inadequate for the foundation of a Professorship; and there does not appear any prospect of further contributions from private sources for carrying out that project.

"Those who were intimately associated with Dr. Todd, and interested in his literary labours, desire that steps should now be taken for a permanent and effective Memorial to him, in the form which they believe would have been most gratifying to himself in his lifetime.

"After careful consideration it appears to them that the following would be the best course to adopt as ensuring a lasting literary monument to Dr. Todd, and, at the same time, most effectually promoting the linguistic and historical studies in which he was so long engaged.

"It is proposed to publish as a Memorial Volume, commemorat of Dr. Todd, for presentation to the chief Public Libraries of Eur and America, a photographic reproduction of *Lebhar mór Lecain*—T Great Book of Lecan—a large and unique Irish Manuscript, transcril from old materials in the fifteenth century, and now preserved in t Library of the Royal Irish Academy. The *Great Book of Lecan* co sists of about 650 folio pages, in double columns, and is the most i portant unpublished Irish Manuscript of its class in Ireland. place its contents beyond the risk of destruction, and to render th accessible to the learned world, would be one of the greatest boo possible to confer on students of the branches of knowledge to whi Dr. Todd devoted so much of his attention. Such a publication wou unquestionably give a great impetus to scientific and accurate Celtolog

"It is calculated that the sum already subscribed, with the amoun likely to accrue from further Subscriptions for copies of so valuabl publication, would probably defray the cost of the work—inclusive a history of the Manuscript, description of its contents, analytic tables, indices, &c., on the plan of the volumes published under n direction by the Royal Irish Academy.

"It is intended that each subscriber of £5 shall receive a copy of t work, and that those who have subscribed less than £5 may obta copies by increasing their contributions to that amount. Should th not desire to do so, they will receive copies of the printed descripti of the Manuscript, without the photographic portion. Each su scriber of £10 and upwards to receive a special copy of the comple work on extra-sized paper.

"The adoption of the course here indicated for the Memorial ha received the warm approval of the friends of Dr. Todd, whose nam and Subscriptions are noted on the other side; and should you desir to co-operate, I beg that you will return the enclosed form, with you signature, to

"Your obedient Servant,

"JOHN T. GILBERT,

"*Treasurer, Todd Memorial.*

"J. K. INGRAM, ESQ."

The following have desired that their Subscriptions shall be applied to the publication of the *Book of Lecan* as the "Todd Memorial":—

	£	s.	d.
Rt. Rev. C. Graves, Bishop of Limerick, .	10	0	0
Rt. Hon. Lord Talbot de Malahide, . .	10	0	0
Very Rev. Dean W. Reeves, Armagh, .	10	0	0
Sir T. A. Larcom, Bart., ...	5	0	0
W. H. Hardinge, Esq., ...	5	0	0
John R. Garstin, Esq., J. P., ...	5	0	0
W. J. O'Donnavan, LL. D., ...	5	0	0
John T. Gilbert, F. S. A., ...	5	0	0
His Grace the Duke of Leinster, . .			

[c.]

"Todd Memorial Fund.

"37, North Great George's-street,
"Dublin, 24*th January*, 1879.

"Sir,

"Referring to the Resolution passed at the Public Meeting of the Subscribers to the Todd Memorial Fund, held at Molesworth Hall, on 27th October, 1869, 'That the National Testimonial to the late Rev. J. H. Todd shall take the form of a Professorship of the Celtic Languages, to be founded in connexion with the Royal Irish Academy,' and to a Circular signed by you as 'Treasurer to the Todd Testimonial Fund'—issued as from the 'Royal Irish Academy, 19, Dawson-street,' about the month of November last, to a selected number of the Subscribers—in which you invite adhesion to a proposal for applying the Fund to a different purpose, we are instructed by Sir Samuel Ferguson, Q.C., who is a Subscriber to the Fund, to inform you that he is advised that, by the Resolution in question, a Charity Trust has been created which cannot be altered without the assent both of the Subscribers in Public Meeting duly assembled, and of the Royal Irish Academy; and we are respectfully to caution you (the more especially as by the death of your Co-treasurer, W. H. Hardinge, Esq., LL.D., on the 20th inst., you have become sole surviving Treasurer) against dealing with the Fund for any but the purpose so resolved on, unless and until such purpose shall be altered by competent authority.

that he shall receive due notice of any further pro
by Public Meeting or otherwise, which may be taken
Fund. We hold Sir Samuel Ferguson's draft for the
which we are prepared to pay over to the credit of
as a new Joint-treasurer shall be appointed in
Hardinge.

"It appears that, with the sanction of the Co
Irish Academy, a Committee, of which you were
the Royal Irish Academy House, in and after Nov
received Subscriptions there, for the purpose of carry
Resolution. The form of Memorial resolved on is sta
issued by that Committee to 'have the fullest approval
relatives of the late Dr. Todd,'—an approval which
to have been procured for the scheme you propose t
has, therefore, been thought proper that copies of thi
sent to the Very Rev. Dean Reeves and J. R. Garstin
surviving Secretaries of that Committee; to your surv
the Rev. Maxwell Close; to the personal represent
Mr. Hardinge, one of the Trustees on whose behalf
make the re-payment of Sir Samuel Ferguson's Sub
Right Rev. the Bishop of Limerick, who, you stat
proposed change in the application of the Funds;
Todd, LL.D., Q.C.—which will account to you for thi
communication.

"We are, Sir,

[d.]

"Todd National Memorial.

"Royal Irish Academy House,
"19, Dawson-street, Dublin,
"10*th February*, 1879.

"We hereby convene a Meeting of the Committee appointed to rry out a Resolution for establishing as a Memorial of the late ev. James Henthorn Todd, D.D., S.F.T.C.D., &c., a Professorship of e Celtic Languages in connexion with the Royal Irish Academy, to held at the Academy House, 19, Dawson-street, Dublin, on Friday e 21st instant, at four o'clock, p.m., for the purpose of filling, if so cided, the Joint-treasurership vacant by the death of W. H. ardinge, Esq., and Joint-secretaryship, vacant by the death of . B. Dobbin, Esq., and to transact such other business as at the eeting may be determined upon.

"William Reeves, D.D., M.R.I.A.,
Dean of Armagh,
"John Ribton Garstin, M.A., M.R.I.A., F.S.A., } *Secretaries*."

[e.]

Resolved—

"That in the event of the 'Todd National Memorial Fund' nounting to a sum equivalent to not less than £1100 of Three per nt. Government Stock, the Council will be prepared to advise the cademy to accept the said Fund, and will undertake the duty of om time to time selecting an Academy's Todd Professor of the Celtic anguages, of defining his status and duties, and settling his remunetion—not to exceed, so far as it is derived from the Memorial und—the annual income thereof."

[F.]

"High Court of Justice (Ireland),
"*Chancery Division.*

"In the Matter of the Trusts of 'The Todd National Memorial Fund;' and the 11th and 12th Victoria, chap. 68.

I, John Thomas Gilbert, of Vil Nova, Blackrock, in the County Dublin, Esq., make oath and say follows:

1. My name is John Thomas Gilbert, and my address is Vil Nova, Blackrock, in the County of Dublin.

2. I may be served with any petition, or any notice of any pr ceeding or order of the Court relating to the trust fund, at the offi of my solicitor, Mr. Thomas Donnelly, of No. 27, Dame-stre Dublin.

3. I propose to transfer the sum of one thousand two hundr and nine pounds eighteen shillings and fourpence, Government Ne Three per cent. Stock, and to pay into Court the sum of twel pounds and four pence cash to the credit of the trust, after deductin the sum of eight pounds for the costs of bringing same into Court.

4. After the death of the late Reverend James Henthorn Tod D.D., S.F.T.C.D., a public Meeting for the purpose of promoting testimonial to his memory was, on the 27th day of October, 186 held at the Molesworth Hall, Dublin, the Very Reverend Willia Atkins, D.D., Dean of Ferns (since deceased), in the chair; and was by the said meeting Resolved, on my motion, seconded by th Reverend Professor Jellett, F.T.C.D., and taken down in writing i the Minute-book of said Meeting, and signed by the Chairman there that the national memorial to the late Rev. J. H. Todd shall take th form of a Professorship of the Celtic Languages, to be founded in con nexion with the Royal Irish Academy; and at a Meeting of Committee the subscribers to said fund held on the 3rd November, 1869, Willia Henry Hardinge and I were appointed Honorary Treasurers of the fun to be raised, which was called "The Todd National Memorial Fund, and the Reverend William Reeves, D.D., Henry Brook Dobbin, an John Ribton Garstin were appointed Honorary Secretaries, and a ver large number of persons, exceeding one hundred in number, wer

appointed a Committee; and it was requested that Subscriptions should be sent to the said William Henry Hardinge and myself as such Honorary Treasurers, or to the local Honorary Secretaries, Sir William Tite, M.P., F.R.S., and William Chappell, Esq., F.S.A.

5. A considerable amount of Subscriptions, including the sum of five pounds each from the said William Henry Hardinge and myself, were sent in, amounting in the whole to a sum of about nine hundred and fifty pounds, and same were, from time to time, invested by the said William Henry Hardinge and myself in the purchase of Government New Three per cent. Stock. In addition to the sum so subscribed, in the month of February, 1871, the Reverend Maxwell Close deposited with the Committee a sum of one hundred pounds in cash, to be added to the amount then subscribed, provided a further sum of one hundred pounds should be contributed by the 1st of November then next, and the said sum of one hundred pounds was invested by the said William Henry Hardinge and myself in the purchase of one hundred and seven pounds twelve shillings and eight pence Government New Three per cent. Stock, in the joint names of the said William Henry Hardinge, myself, and the said Reverend Maxwell Close, and same now stands in the said three names in the books of the Governor and Company of the Bank of Ireland; but the dividends on said sum of Stock have been, from time to time, invested by me and the said William Henry Hardinge, in the names of myself and said William Henry Hardinge, and form part of the said sum of Stock proposed to be transferred by me; and the dividends on all the said Stock were re-invested from time to time, and such Stock now amounts to the sum of one thousand two hundred and nine pounds eighteen shillings and four pence; and the Stock and cash intended to be transferred and brought into Court by me is the entire amount of such Subscriptions and investments, and recently accrued and uninvested dividends, after deducting the aforesaid sum of eight pounds, and the sum of four pounds seven shillings and four pence for the costs of and incidental to the taking the opinion of counsel as to the course to be pursued by the trustees, and the sum of five pounds nine shillings and seven pence paid by me for printing and sending out the circular mentioned in the next paragraph hereof.

6. The said sum of one thousand two hundred and nine pounds eighteen shillings and four pence is wholly insufficient to endow and

support the proposed Professorship, and it has been, in consequence, proposed that, in lieu of such Professorship, and as a memorial to Dr. Todd, and with a view to promote Celtic studies, a photographic reproduction of the great Book of Lecan, an unique and most important unpublished collection of ancient Celtic literature belonging to the Royal Irish Academy, should be published as a memorial volume, and such last-mentioned proposal has been approved of by a large number of influential Subscribers and by eminent Celtic scholars, as tending pre-eminently to promote the knowledge of Celtic languages, which cannot, it is believed, be fully investigated so long as the said book remains unpublished.

7. The said William Henry Hardinge and I commenced the issue of a circular, inviting Subscribers to inform us if they would approve of such last-mentioned proposal, and caused same to be sent to several of the Subscribers, and it would appear that such proposal is disapproved of by some Subscribers, and, amongst others, by Sir Samuel Ferguson, Q.C.; and believing it to be our duty to return the Subscriptions of those who dissented from the said last-mentioned proposition, I consequently lodged to the account of the said Sir Samuel Ferguson with his bankers the sum of five pounds; and to the account of John Kells Ingram, Esq., the sum of ten pounds, as his Subscription of five pounds, and a like amount as the Subscription of his brother, believed now to be abroad, to said fund; and I have received from Messrs. Maxwell & Weldon, as solicitors for the said Sir Samuel Ferguson, a printed protest, dated 24th of January, 1879, and upon which I have endorsed my name at the time of swearing this affidavit, repudiating the return of his Subscription, and cautioning me against dealing with the fund for any but the original purpose; and as there would appear to be a difference of opinion among influential Subscribers, I am desirous to be relieved of any responsibility as to the application of the fund, and I have not made any deduction from the amount of the Stock transferred or cash paid into Court by me in respect of the three said Subscriptions so returned by me.

8. My Co-trustee, the said William Henry Hardinge, died on or about the 21st day of January, 1879; consequently, I am now sole Trustee, and there does not appear to be any person to appoint a new trustee in his place, and for the protection of the fund, as well as

MONDAY EVENING, MAY 12, 1879.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Rev. Terence O'Rorke, D.D., was elected a Member.

Professor O'Reilly read a Paper "On a Cylindrical Mass of Basalt existing at Contham Head, Moon Bay, Coast of Antrim." [Vide *Proceedings*, vol. iii., series ii., Science, part 3, p. 237.]

The Secretary read a Series of Mathematical Notes, by Mr. Anglin, which were communicated by President Sullivan.

Professor E. W. Davy, M.D., read a Paper, "Notes on some Observations on Nitrification." [Vide *Proceedings*, vol. iii., series ii., Science, part 3, p. 242.]

MONDAY EVENING, MAY 26, 1879.

VERY REV. DEAN REEVES, D.D., Vice-President, in the Chair.

Mr. Stephen Tucker, Rouge Croix, and Mr. W. J. Doherty, C.E., were elected Members.

Mr. P. C. E. Burton read a Paper "On recent Researches respecting the *minimum visibile* in the Microscope. [Vide *Proceedings*, vol. iii., series ii., Science, part 3, p. 248.]

Very Rev. Dean Reeves read a communication relative to a letter received from the Lord Bishop of Killaloe, from the late John Forster, on a circumstance connected with his memoir of Dean Swift. [Vide *Proceedings*, vol. ii., series ii., Polite Literature and Antiquities, part 1, p. 4.]

The thanks of the Academy were voted to the Lord Bishop of Killaloe, for the donation of the letter.

MONDAY EVENING, JUNE 9, 1879.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

The President announced with great regret the death of our esteemed Member, David Moore, PH.D., Director of the Botanic Gardens at Glasnevin.

Dr. W. Frazer read a Paper "On a Medal of the Delivery of

Antwerp, in 1577." [Vide *Proceedings*, vol. ii., series ii., Polite Literature and Antiquities, part 1, p. 7.]

Dr. W. Frazer exhibited an Irish Harp of the time of Elizabeth, or James I. He also exhibited, on behalf of Mr. Henry Keogh, of Roundwood House, Co. Wicklow, some objects from the ruins of Knock-a-Temple Church at Roundwood.

The objects included a large rivetted Bronze Bell, the figure of a Human Head carved in freestone, an English Coin of the date of Henry III., and a Scotch Coin of Alexander III., a portion of a glass Patera, a Button of Mica Schist, and other small objects. [Vide *Proceedings*, vol. ii., series ii., Polite Literature and Antiquities, part 1, pp. 9 and 12.]

The thanks of the Academy were voted to Mr. Keogh, for his kindness in submitting these objects to the inspection of the Academy.

By permission of the Academy, Mr. C. C. Hutchinson, Associate, Royal College of Science, Ireland, read a Paper "On a convenient available Source of Heat for Laboratory purposes."

The following Recommendation from the Council was adopted:—

"To recommend the Academy to vote the sum of £25 for the purchase of certain documents which will be of value for the continuation of the Catalogue of the Museum."

MONDAY EVENING, JUNE 23, 1879.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Mr. B. Williamson, M.A., F.R.S., F.T.C.D., signed the Roll, and was admitted a Member.

By permission of the Academy, Mr. John Dreyer, Assistant Astronomer at Dunsink Observatory, read "A Note on the Meteors connected with the first Comet of 1870." [Vide *Proceedings*, vol. iii., series ii., Science, part 4.]

Mr. Samuel Ferguson read a Paper "On a Passage in the Confessio Patricii" (No. 2). [Vide *Proceedings*, vol. ii., series ii., Polite Literature and Antiquities, part 13.]

Mr. George Porte read a "Report of Experiments and Researches in Micro-Photography."

Dr. George Sigerson, read a Paper "On a contribution to the

Study of Nerve Action in connexion with the sense of Taste." [Vide *Proceedings*, vol. iii., series ii., Science, part 4.]

Professor J. P. O'Reilly, C.E., exhibited to the Academy a set of eleven Maps, by Florentino Alueno Secco, dated 1600, giving amongst others a map of Central Africa, with the recent discoveries of the Source of the Nile, and the course of the Congo.

The following Recommendations from Council were adopted:—

To allocate £50 to a Committee, consisting of Mr. G. H. Kinahan, Mr. Ussher, and Mr. Leith Adams, for the purpose of exploring the Cappagh Caves near Dungarvan.

To allocate £15 to Professor J. Emerson Reynolds, for the purchase of a considerable quantity of Sulpho-urea to make experiments on the comparative actions of the Isomeric bodies, and Sulpho-cyanate of Ammonium, and the Sulpho-urea, on the growth of certain plants.

To allocate £50 to Messrs. Kinahan and Baily, for the purpose of investigating the fossils and igneous rocks of Curlew and Fintona Beds.

MONDAY EVENING, NOVEMBER 10, 1879.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Dr. W. Frazer, F.R.C.S.I., read a Paper "On the Discovery of Danish Weapons, and a quantity of Human Remains recently found near Donnybrook."

Dr. E. Perceval Wright, read Papers—

1. "On a New Genus and Species of Sponge, with heteromorphic zooids."
2. "On two New Species of Thallophytes." [Vide *Transactions*, vol. xxviii., Science, parts 1 and 2.]

Donations to the Library were presented, and thanks voted to the Donors.

SATURDAY EVENING, NOVEMBER 29, 1879.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

(Stated General Meeting.)

Dr. W. Frazer read a Paper "On certain Papers relating to Lady Bellasys and the private history of James II., when Duke of York."

results have been published in the vol

Transactions, have decided that Cunningh

upon Dr. Robert S. Ball, Astronomer R

searches in Mechanics; and upon Mr. W

gical Investigations. In now presenting

and of the Academy, those medals to o

I shall endeavour, though very briefly, to

Members the grounds on which those h

made.

Dr. Ball's title to an eminent position i

and in this Academy, might claim the san

claim which those who, like myself, hav

vantage of association with his esteemed f

promotion of scientific objects to which n

position of this Academy is due—would b

he can afford to waive even such well-foun

and respect, and to leave his claims to the

now about to receive, on his own individu

the Academy.

Having devoted himself specially to th

matical and Physical Sciences, Dr. Ball h

Mathematics in the Royal College of Sci

conferred special value and importance b

Practical Mechanics, and by the organizat

sical research and instruction. Those lec

Members of the Academy. It is not, however, for those more popular results of Dr. Ball's labours that the Council have on this occasion showed their sense of his merits as an original thinker and discoverer in Science, but for work of a more recondite character, the nature of which is much less capable of popular description, but the value and importance of which has been abundantly vouched for by the suffrages of eminent mathematicians throughout Europe. I refer to the series of Memoirs published partly in our *Transactions*, and partly in those of the Royal Society of London, and finally completed and published in a separate and independent form in his work on the *Theory of Screws, a Study of the Dynamics of a Rigid Body.*

In this remarkable work, which is based mainly on the application of the principles of the new linear geometry, which we owe to the labours of Poinsot, of Plücker, and of Chasles, Dr. Ball studies the kinematics, equilibrium and small oscillations of a rigid body. The direct problem to be dealt with may be thus stated:—To determine at any instant the position of a rigid body subjected to certain constraints, and acted on by certain forces. Adopting one position of the body as a standard of reference, a complete solution of the problem must provide us with the means of deriving the position at any subsequent epoch from the standard position. Then arises the inquiry into the most natural method of specifying one position of a body with respect to another. It had been established by Poinsot that a force and a couple perpendicular to the force constitute what may be called the canonical form of a system of forces applied to a rigid body, and it was discovered by Chasles that the canonical form of the displacement of a rigid body consists of a rotation about an axis combined with a translation parallel to that axis. We can thus, in the method used by Dr. Ball, have a movement prescribed by which the body can be brought from the standard position to the sought position; a certain axis can be found, such that if the body be rotated around this axis through a certain angle, and translated parallel to the axis for a certain distance, the desired movement will be effected.

It will simplify the conception of the movement to suppose that at each epoch of the interval of time occupied by the operation for producing the change of position, the angle of rotation bears to the final angle of rotation the same ratio which the corresponding translation bears to the final translation. Under these circumstances the

motion of the body is precisely the same as if it were rigidly attach
to the nut of a screw (in the ordinary sense of the word), which h
an appropriate position in space, and an appropriate number of thre
to the inch. Hence, it may be stated that the canonical form to whi
all the forces acting on a rigid body can be reduced is a wrench on
screw. By such conception it is shown by Dr. Ball the solution
any problem in the dynamics of a rigid body may be presented. T
complete solution of such a problem must provide at each epoch
screw by a twist about which, of an amplitude also to be specified, t
body can be brought from a standard position to the position occupi
at the epoch in question. I do not think it necessary, on this occ
sion, to enter further into the details as to the methods employed, a
the results obtained by Dr. Ball in these researches; suffice it
observe, as to their power and generality, that, limited only by t
condition that the body, while the object of examination, remains in
indefinitely adjacent to its original position, the restricted inquiry st
includes the complete theory of equilibrium, of impulsive forces, a
of small oscillations of rigid bodies.

It would not, however, sufficiently indicate the services render
to Science by Dr. Ball were I to omit to state that, since the transf
of his labours from the Royal College of Science to the Universi
Observatory at Dunsink, he has zealously devoted himself to tho
astronomical researches for which a remarkable combination of math
matical and mechanical ability have so highly qualified him. Alrea
he has laid before this Academy several memoirs embodying valuab
observatory work, and I understand that researches now in progre
especially as regards the important subject of parallax, promise
afford results which will redound to the credit of the University a
of this Academy.

The President then delivered the Medal to Dr. Ball, and pr
ceeded:—

The history of the gradual development of our knowledge of t
lower forms of animal and vegetable life presents a subject of gre
and popular interest; but on this occasion I feel it my duty to lim
myself to such observations as are requisite to explain to the Membe
of the Academy the special grounds on which the Council decided
signalise the services rendered by Mr. Archer to this department
Science by the award of a Cunningham Medal. It is only since th

early part of the present century that naturalists have learned to recognise, that by a close and attentive study of the lowest and simplest forms of animal and vegetable life could they alone hope to arrive at an accurate idea of the elementary structure of organised tissues, or a knowledge of the processes by which the growth and development of living beings are effected. As the chemist proceeds in his inquiries to separate the more complex compounds into their elementary constituents, and then synthetically to reunite those elements into combinations of continually increasing complexity and mass, so the naturalist has learned to seek for the laws of organisation in the simplest forms by which life is manifested, and to study the initial forces of vitality in the properties of the elemental cell. Thereby was that Protean material revealed, not inaptly called the physical basis of life, the protoplasm, coextensive with the organic world, bound up with every vital act, from the lowest organism up to the very highest. For this study the biologist must investigate the structure and functions of unicellular plants and animals; then he will find that in both great divisions of the organic world the protoplasm is in its essential nature the same, whilst in individual species in both kingdoms it may nevertheless manifest subtle characteristic differences of aspect and behaviour. Being throughout an albuminoid tenacious semifluid, more or less mobile, it is possessed of an innate irritability; totally destitute of visible structure, although living; itself unorganised, it is yet the builder up of all organisation: watched under the microscope in the living state in some of the simplest sarcodines, this truly marvellous material can be seen altering its outline, sending forth and retracting prolongations of its substance, the so-called pseudopodia, along which the more liquid portions of its mass appear often to ramify and inosculate. Such researches into the problem of life, as manifested by those humble and elemental forms, standing as it were on the threshold of existence, have thrown a wondrous light on many a dark puzzle as to growth and development.

The origin of this department of Science is completely modern; scarcely dating from the middle of the present century. Numerous enthusiastic workers on the Continent and in great Britain have, however, rapidly raised it to its present importance as the basis of philosophical biology. The names of Berkeley and Hassall, of Ralfs and

Braün, of Nageli and Pringsheim, are but a few of those wh labours should well deserve to be recorded; some of whom still rem labourers in the field of biological science actively augmenting t growing importance of their studies. The peculiar nature of th beings which form, for the most part, the objects of their inquir facilitates their investigations. Wherever the foot of man can tre those minute and simple beings are to be met with; no costly expe tions are needed to collect them; each sea, and every land, affords th special forms; the upland lake, the marshy pool, the air itself, affor fruitful material for inquiry. In our own country such localiti abound, but until lately this branch of biological science did not a pear to attract much notice when Mr. Archer showed that our fres water ponds possessed representatives of diverse types, some of exqu site beauty, and kindred with even tropical forms.

Since that time our esteemed colleague has devoted himself, wi a patient assiduity and a microscopic tact which is beyond praise, this class of researches, and his spirit of inquiry and honest love truth has afforded him an abundant harvest of important and interes ing results, to a few of which I shall very briefly direct attention. 1855, Mr. Archer laid before the Zoological and Botanical Associati of the University of Dublin a Catalogue of the Desmidieæ of t County of Dublin. This was followed up in the ensuing spring a supplemental list. Modestly styled a Catalogue, these two memo constituted excellent original essays on the species forming that grou giving descriptions of new genera and species, illustrated by drawin from the author's hand. By this publication Mr. Archer took at on a high place among original investigators; and when the long illn of Mr. Ralfs prevented him from revising the new edition of t Desmidieæ for Pritchard's well-known work on the Infusoria, the ta was committed to Mr. Archer's care. Since that time a long ser of Papers on these subjects has flowed from his pen, so that now, every work relating to that class of organisms, one finds our co league's name and labours referred to as an authority. I need n detain you with a long list of those Papers, contenting myself wi the statement that by them our knowledge of the unicellular and fi mentous algæ has been largely increased.

The close relation between the two kingdoms of organic natu especially in their lowest and more elemental forms, necessarily lea

the investigator of the phenomena of vegetable life to consider also the correlative forms of animal existence at once analogues and competitors in the great struggle for existence. So, from the contemplation of plant life Mr. Archer was led to the study of animal life as manifested in its lowest forms. His studies were rewarded by a very brilliant series of discoveries Among the group of the Rhizopods, not only new species and genera, but several new families, have been discovered and described by him. Chief among those memoirs I may mention those in our own *Proceedings* "On some new or little known freshwater Rhizopods," that, "On Chlamydomyxa labyrinthuloides, a new freshwater sarcode organism," and those in the *Quarterly Journal of Microscopical Science* "On some freshwater Rhizopods," in which he described that beautiful form called by him "Rhaphidiophrys viridis," still the noblest known form of freshwater Rhizopods. Not only was the discovery of these new creatures a subject for congratulation, but the painstaking way in which their life-history was studied and recorded will always remain a pattern for such work in future. His Paper also "On Ballia callitriche," published in the Linnean Society's *Transactions*, describing the structure and cell development of one of the higher algæ, has been received as a most valuable contribution to our knowledge of cell-evolution.

I am sure that the Academy will fully approve the judgment of the Council in awarding to Mr. Archer a Cunningham Medal in recognition of the merit he has shown in these varied and interesting researches; and in presenting him therewith, I venture to express my hope that he may be able to prosecute still further a line of research in which he has already been so successful.

The President then presented the Medal to Mr. Archer.

Mr. G. H. Kinahan read a Paper "On a Submarine Crannog, at Ardmore, Co. Waterford."

Alexander Macalister, M.D., was elected to the place on the Council vacant by the death of David Moore, PH.D.

Donations to the Library were presented, and thanks voted to the Donors.

Dr. John Casey read a Paper "On Cubic Transf
CUNNINGHAM MEMOIRS, No. 1.]

Mr. Philip Burton read a Paper "On a Phen
observed in Fogs."

Dr. N. Furlong read a Paper "On the occasi
a Polar arrangement of Clouds, with its possible re
ture."

Mr. Edwin Hamilton, M.A., was elected a Memb

Donations to the Library were presented, and t
the Donors.

MONDAY EVENING, JANUARY 12, 188

A. G. RICHEY, LL.D., Q.C., Vice-President, in

The Treasurer read a Paper by Mr. Thomas Pl
Sepulchral Remains found in Killicarrey, Co. Cavan.

The Secretary read a further Paper by Mr. A. I
"Mathematical Notes."

Donations to the Library were presented, and tl
Donors.

MONDAY EVENING, JANUARY 26, 188(

REV. S. HAUGHTON, M.D., F.R.S., Vice-President

Curlew Mountain Districts, with Palæontological Remarks, by W. H. Baily," was taken as read.

By the permission of the Academy, T. J. B. Quinlan, M.D., read a Paper "On the application of Spectrum Analysis to the Estimation of Bile in the Renal Secretion, in cases of Jaundice." [Vide *Proceedings*, vol. ii., series ii., Science, part 4.]

The following Grants, recommended by the Council, out of the Parliamentary Grant for the preparation of Scientific Reports, were adopted:—

£10 to R. M. Barrington, to enable him to investigate the Flora of the Blaskett Islands.

£10 to Mr. H. C. Hart, to enable him to investigate the Flora of the Galtee Mountains.

£20 to Mr. Phineas S. Abraham, to assist him in the Microscopic Studies of the Marsupial Tissues.

Donations to the Library were presented, and thanks voted to the Donors.

MONDAY EVENING, FEBRUARY 9, 1880.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

The following Resolution was unanimously adopted, and the President was requested to communicate it to the family of the late Sir Dominic J. Corrigan, Bart., M.R.I.A.:—

"That the Royal Irish Academy desires to express its deep sense of the loss which Medical Science has sustained by the death of Sir Dominic J. Corrigan, Bart., a distinguished Member of this Academy, and an Ex-President of the King and Queen's College of Physicians in Ireland."

Dr. George Sigerson, CH.M., read a Paper "Contribution to the Study of Nerve Action, in connexion with the sense of Taste." No. 2, "Functions of the Chorda Tympani." [Vide *Proceedings*, vol. iii., series ii., Science, part 4.]

Michael Barry, M.D., Rev. John B. Barter, Thomas Plunkett, John Newsome White, and Agmondisham B. Vesey, L.K.Q.C.P.I., were elected Members of the Academy.

Donations were presented to the Library, and thanks voted to the Donors.

Report from Council, on the death of Mr. Josep
Scribe, to the Academy:—

The late Mr. Joseph O'Longan, as he was prob
was amongst the most distinguished, of Irish Scribe
a family in which this profession was hereditary :
self, his brother, father, and grandfather—all of t
capacity—are not likely to be soon forgotten.

Many products of their skill and industry no
Irish Academy, but the most important work has
accomplished by Mr. Joseph O'Longan, who is just

In early life employed as a schoolmaster in C
National Board—a service which, had he continue
entitled him to retire on a pension—he there made
as an efficient and trustworthy Irish Scribe. Du
have from his hand a beautifully-written copy of th
together with many minor MSS. in the Windele C
death of O'Curry in 1865, Mr. O'Longan was ap
of Irish Scribe to the Academy, which he has held
the early part of this period we have from his h
Index of Subjects and of Initial Lines, of the m
the MSS. of the Royal Irish Academy, a work in si
which enables a reference to be at once made to alm
with in the MSS. The work on which he was sub
was the transcription of the great MSS.—Leabhar

afely asserted that no one who ever saw him work doubted or could loubt his thorough earnestness in the performance of his task. The lifficulty in his case was to prevent his overstepping the bounds of rudence in the work he endeavoured to get through : the Committee f Irish MSS. has had to intervene in the interests of his health, and horten compulsorily the time which he would have devoted to the ervice of the Academy. And his zeal was equalled by his rectitude. The conscientious spirit in which he patiently worked was evident to all who had anything to do with the direction of his labours.

The Salary which the Council could give, from the funds at their lisposal, was but small in consideration of work so faithfully and so oyally performed towards the Academy; and the Council feel that it will only be anticipating the wishes of the Academy in seeking con-ributions towards the support of the family (widow and three laughters) whom Mr. O'Longan's death has left entirely unprovided 'or.

They have therefore drawn up the preceding short notice, and ask he generous aid of the Members of the Academy in support of the ereaved family, as a well-merited tribute to the memory of the leceased.

Subscriptions in aid of the fund will be received by the Treasurer, Rev. M. H. Close, Academy House, Dawson-street.

List of Subscriptions already received—

The President, £3 3*s.*; Robert Atkinson, LL.D., £5; Robert S. Ball, F.R.S., £2 2*s.*; A. Carte, M.D., £2 2*s.*; John Casey, F.R.S., £2 2*s.*; Rev. M. H. Close, M.A., £20; E. W. Davy, M.D., £1 1*s.*; Sir S. Ferguson, LL.D., £2 2*s.*; George F. Fitzgerald, F.T.C., £2 2*s.*; John R. Garstin, F.S.A., £2 2*s.*; John T. Gilbert, F.S.A., £2 2*s.*; Rev. S. Haughton, F.R.S., £2 2*s.*; T. Hayden, M.D., £2 2*s.*; J. K. Ingram, LL.D., £3 3*s.*; Rev. J. H. Jellett, B.D., £2 2*s.*; A. Macalister, M.D., £1 1*s.*; W. J. O'Donnavan, LL.D., £2 2*s.*; J. P. O'Reilly, C.E., £2; Very Rev. Dean Reeves, D.D., £2 2*s.*; A. G. Richey, Q.C., £2 2*s.*; Lord Talbot de Malahide, F.R.S., £2 2*s.*; B. Williamson, F.R.S., £1 1*s.*

Professor J. P. O'Reilly, C.E., read a Paper "On the Lines of Jointing observable about the Shores of the Bay of Dublin, and their relation with neighbouring Coast Lines."

Rev. S. Haughton, M.D., F.R.S., and J. Emerson Re
read their "Report on Experiments made to determine
Air upon Air, and of Water upon Water, at low veloci
Proceedings, vol. iii., series ii., Science, part 4.]

TUESDAY EVENING, MARCH 16, 1880.

SIR ROBERT KANE, LL.D., F.R.S., President, in the C

(Stated Meeting.)

The President declared the Ballot open for the election
of Council. Mr. Latouche and Dr. Sigerson were appointed S

The Secretary of the Council brought up the following:

REPORT OF THE COUNCIL FOR THE YEAR 1879–80.

Since the date of the last Report of the Council, the
Parts of the *Transactions* have been published:—

Vol. xxvii.—*Polite Literature and Antiquities.*

Part 3. "On the Croix Gammée or Swastika." By t
Rev. Charles Graves, D.D., Lord Bishop of Limerick.

Vol. xxvi.—*Science.*

Part 20. "On the Equations of Circles." By J. Casey,

Part 21. "On the Correlation of Lines of Direction on th
Surface." By J. P. O'Reilly, C.E.

Part 22. "Explanatory Notes and Discussion of the Natu
Prismatic Forms of a Group of Columnar Basalts, Giant'
way." By J. P. O'Reilly, C.E.

The following Parts of the *Transactions* are in the Press,
be published immediately:—

Vol. xxviii.—*Science.*

Part 1. "On a new Genus and Species of Sponge."
Wright, M.D.

Part 2. "On two new Genera and Species of Thallophy
E. P. Wright, M.D.

Also of the *Cunningham Memoirs.*

No. 1. "Cubic Transformations." By John Casey, LL.D.

)f the *Proceedings*, part 13 of vol. i. (second series), containing rs on Polite Literature and Antiquities, concluding the volume, published in April, 1879; part 3 of vol. iii. (second series), con-ng Papers on Science, was published in July, 1879; and part 1 of ii. (second series), containing Papers on Polite Literature and An-ties, was published in November, 1879.

Vithin the past year Papers by the following authors were read re the Academy:—

n the Department of Science:—By Rev. Dr. Haughton; Dr. r; Mr. W. L. Peacocke; Mr. C. E. Burton; Mr. C. C. Hutchinson; John E. L. Dreyer; Mr. George Porte; Dr. Sigerson; Professor erceval Wright; Mr. G. H. Kinahan; Mr. J. F. Knott; Professor r; Mr. Philip Burton; Dr. N. Furlong; Mr. A. H. Anglin; W. H. Baily; Dr. F. J. B. Quinlan; Professor J. P. O'Reilly; Professor J. Emerson Reynolds.

n the Department of Polite Literature and Antiquities:—By the Rev. Dean Reeves; Sir Samuel Ferguson; Professor Ingram; G. H. Kinahan; Dr. W. Frazer; and Mr. Thomas Plunkett.

t will be thus seen that, during the season just past, there has no falling-off in the number and importance of the Papers read. Council, having had under consideration the desirability of ob-ng disputes as to the priority of Papers read in the Academy or here, by defining exactly the time at which each Paper was ved and laid before the Academy, have introduced some ges into the method hitherto observed, which, they believe, will nce to the more satisfactory administration of the business of the emy, viz., by requiring that every Paper shall be accompanied by bstract of its contents, and that leave shall not be given to read Paper which is not in the Secretary's hands at the time; the r thus read will be marked with the date of reception, and, if ed, will take priority from that date, no changes being allowed e Paper, except in the form of notes, which shall also bear the of their insertion, after receiving the assent of the Committee of ication. A strict adherence to these rules will lead to the more ly publication of the Papers thus prepared, besides providing for ndispensable determination of the time from which an author can priority for his communication.

'he Council, having for some time past observed with regret that

the funds at their disposal for the publication of the numerous important Papers read before the Academy, were inadequate for the purpose, have had under consideration a plan for allocating more funds to this object, and have adopted a scheme of retrenchment, (which cannot, however, be brought into operation for some time), by which the various functions of the Academy will still be carried on in a suitable manner, at the same time that the publication of Papers shall not receive any disheartening check from deficiency of the necessary means.

The following grants in aid of the Preparation of Scientific Reports have been already sanctioned by the Academy:—

£50 to a Committee consisting of Mr. G. H. Kinahan, Mr. R. J. Ussher, and Professor Leith Adams, for the purpose of exploring the Cappagh Caves, near Dungarvan.

£15 to Professor J. Emerson Reynolds for the purchase of a considerable quantity of Sulpho-Urea to make experiments on the comparative actions of the Isomeric Bodies, Sulpho-Cyanate of Ammonium, and Sulpho-Urea, on the growth of certain plants.

£50 to Messrs. G. H. Kinahan and W. H. Baily for the purpose of investigating the Fossils and Igneous Rocks of the Curlew and Fintona Beds.

£10 to Mr. R. M. Barrington to enable him to investigate the Flora of the Blaskett Islands.

£10 to Mr. H. C. Hart to enable him to investigate the Flora of the Galtee Mountains.

£20 to Mr. Phineas S. Abraham to assist him in the Microscopic studies of the Marsupial Tissues.

Attached is a schedule (Appendix A.) giving information as to the progress of the Reports for which Grants from this fund have been made from time to time, and it is the earnest wish of the Council that the Secretaries be informed, at as early a date as possible, of the state of the investigations for which the grants were made, and of the probable time when the Reports thereon may be expected.

While the above statement sufficiently testifies to the activity of the Academy on the side of science, the antiquarian interests have not been neglected. Considerable progress has been made in the department in which the Academy is naturally expected to aid the prosecution of research, viz., in the advancement of Celtic studies.

The Council having had under consideration the importance of bringing into more manageable bounds the enormous masses of information scattered in various works on the early history of Ireland, have offered a prize of £100 for the best Dictionary on the model of a classical dictionary, containing a digested account of all names of persons and places to which reference is made in the facsimiles published by the Academy—a term of three years being fixed as the limit within which the prize can be obtained.

A still more important step in the direction of securing proper attention to Celtic studies has been taken by the Council during the past year, in accordance with the decision of the Academy. In endeavouring to carry out the purpose of the Todd Memorial Fund, the Council have appointed Mr. Maunsell Hennessy as the first Todd Professor of the Celtic languages; to which end measures are being taken that the necessary funds may be drawn out of Court, so that the Todd Professor will, it is hoped, be enabled to deliver four lectures on subjects connected with his Chair during the ensuing year.

On the other hand, the Council regret to report the serious loss that has befallen the Academy, in the death of its Irish scribe, Mr. Joseph O'Longan. They have already in a communication to the Academy expressed their deep sense of the value of Mr. O'Longan's services, and have addressed to the Members, on behalf of his family, an appeal to which they have generously responded. His unexpected death has, as was natural, put a stop for the time to the work of the transcription of Irish MSS., by which the Academy has sought to place its literary wealth at the disposal of a wider circle of scholars, and so facilitate the speedier sifting of the historical and philological materials in the possession of the Academy. It is hardly necessary to add, that negotiations are in progress with a view to secure the satisfactory continuation of this desirable work, but the arrangements will take some little time to mature. The Council expect, however, that the work will be shortly resumed, and that the new arrangements when completed will, besides, tend to the accumulation of suitable material for the great desideratum in these studies—a trustworthy Irish Dictionary.

In another branch of this department of Celtic studies, the Council report that, as the slow progress of the work of carrying through

the press the *Táin Bó Cualnge* gave no hopes of its being finish
within any reasonable time, and as they found it impossible to i
fluence the rate at which its preparation was proceeding—the w
being practically in the same condition as it was some years ag
they have felt bound to order its discontinuance. This, however,
now of the less consequence, as the original tale itself will be pla
in the hands of scholars almost immediately, in the fac-simile of t
Book of Leinster.

Of this last work, the whole of the transcription was finished
Mr. O'Longan; all the introductory matter is completed, comprising
analysis of the contents, and suitable indices, so that its immedi
publication may be expected.

The *Book of Ballymote*, the next of the great MSS. proposed to
published in fac-simile, was just begun when the death of t
transcriber suspended the work: pages 1–16 are printed off, a
pages 17–29 are on the stone.

In the case of the *Annals of Ulster*, the Council are glad to rep
that the preparation of that work for the press is now in a forwa
state, and the editor, the Very Rev. Dean Reeves, has announced
expectation that "the printing of the work will commence in t
course of the present month."

The *Felire of Oengus* is also progressing favourably, and thou
the anticipations of the Council as to its publication during t
present session have not been fulfilled, the work has yet advanced
far, that its publication cannot now be long delayed. The body
the work itself is printed off, and the whole of the Glossarial Index
also in type: there now remains, to complete the work, only t
Introduction, the whole of which is in the printer's hands.

In the internal arrangements of the Academy House some im
portant improvements have been introduced, under the direction
the proper authorities.

The glazed desk-cases alluded to in the last year's Report hav
been completed, and are now set up in the Gold Room of the Museum
With the adjacent horizontal window-cases, they afford the space
long needed, for the exhibition of numerous gold objects hitherto t
crowded to admit of satisfactory inspection.

Considerable repairs have been effected, in addition, in vario

parts of the Academy House. The main staircase has been painted throughout, and the Reading-room has been re-decorated.

Another measure, referred to in last year's Report, has been carried out, in order to the greater security of the Academy's treasures, in the provision of a spacious fire-proof safe, in which are now deposited the most precious of the MSS. belonging to the Academy.

During the past year many valuable objects have been added to the collections in the Academy, comprising—fibulæ of gold, bronze weapons and implements, fictile and wooden vessels, an ancient Irish "skin-hood," and a crozier-head of white bronze plated with silver, a most interesting example of mediæval Irish art.

The Library, besides the ordinary additions by way of exchange and purchase, among other donations, has received, by the bequest of Sir Thomas Larcom, the valuable present of upwards of 300 volumes, all of which have been duly catalogued and made accessible to the Members of the Academy. Another important addition has been made also, in the acquisition of a body of papers, the work of the late Sir William Wilde, containing material for the continuation of the Catalogue of the Museum.

In addition, the Library has been honoured with a welcome present from the Government of France, consisting of fifteen volumes of the *Documents Inédits sur l'Histoire de France.*

In accordance with the request of the Moore Centenary Committee and of the Lord Mayor of Dublin, the Council lent to that Committee various objects in the possession of the Academy, which had belonged to Thomas Moore, to form part of a collection of mementos of the poet, to be exhibited on the occasion of the Centenary celebration. All the objects have since been safely restored.

In the Session just past, Cunningham medals were awarded to the following members of the Academy—

Robert S. Ball, LL.D., F.R.S., and
William Archer, F.R.S.;

to the former for his Researches in Mechanics, to the latter for his Biological Researches. The cordial approval of the Academy in sanctioning

these awards found a fitting exponent in the President' who, in his address on the occasion of presenting the medals, made suitable reference to the labours that had gained for these two gentlemen the honourable distinction awarded them by the unanimous suffrages of the Academy.

In addition, Dr. Casey's Paper, on *Cubic Transformations*, has been deemed worthy of being printed as a Cunningham Memoir, in accordance with the provisions for the disposal of the Cunningham Fund.

The following Ordinary Members have been elected since the 16th of March, 1879:—

1. Thomas Dunbar Ingram, LL.B.
2. Rev. Terence O'Rorke, D.D.
3. Stephen Tucker, Rouge-Croix.
4. W. J. Doherty, C. E.
5. Edwin Hamilton, M. A.
6. Thomas Plunkett.
7. Rev. John B. Barter.
8. John Newsome White.
9. Michael Barry, M.D.
10. Agmondisham B. Vesey, L.K.Q.C.P.I.

We have lost by death within the year four Honorary Members. In the Department of Science:—

1. Bernard Von Cotta.
2. Heinrich Wilhelm Dove.
3. Johann Von Lamont.

In the Department of Polite Literature and Antiquities:—

1. Major-General Sir Thomas A. Larcom, K.C.B.

And sixteen Ordinary Members:—

1. William Andrews, elected January 10, 1842.
2. Charles Benson, M.D., elected November 30, 1825.
3. Rev. Robert G. Cather, elected January 13, 1862.
4. Sir Dominic J. Corrigan, Bart., M.D., elected January 1[illegible] 1847.
5. James Gibson, Q.C., elected January 13, 1851.
6. Charles W. Hamilton, elected April 25, 1836.
7. Nathaniel Hone, elected April 12, 1847.

8. J. J. Kelso, M.D., elected November 8, 1869.
9. Sir T. A. Larcom, K.C.B., elected November 30, 1833.
10. C. Lloyd, M.D., elected May 14, 1877.
11. Sir John MacNeill, F.R.S., elected February 21, 1831.
12. David Moore, Ph.D., elected June 23, 1845.
13. Rev. T. H. Porter, D.D., elected April 25, 1836.
14. Very Rev. C. W. Russell, D.D., elected February 10, 1868.
15. H. H. Stewart, M.D., elected April 11, 1853.
16. A. Thom, elected June 11, 1866.

In addition to the distinguished name of Corrigan, whose labours have been more appropriately commemorated in the memoirs of other Societies devoted to the studies of his profession, there appear in the above list the following names, which call for some special mention in the present Report:—

William Andrews, from his youth, and during his long life, was an ardent field naturalist. He made many valuable additions to the flora and fauna, especially the marine ichthyology, of the South West of Ireland: among his discoveries should be particularized *Geomalacus maculosus* (Allman), a beautiful gasteropod, occurring in Co. Kerry. His memory will be deservedly perpetuated in the name given by Edward Newman to another of his discoveries, *Trichomanes Andrewsii* (a remarkable variety of *T. radicans*), and in that of *Galathea Andrewsii* given to a crustacean by Dr. John Kinahan. Mr. Andrews was one of the chief founders and promoters of the Natural History Society of Dublin, of which he was at one time President, and for a considerable period Secretary. He was also for many years Chairman of the Natural History Committee of the Royal Dublin Society. He contributed to the Proceedings of the Academy, in 1844, a Paper on *Trichomanes* and *Hymenophyllum*; and in 1867 and 1870, two communications recording the finding in those years of the rare cetacean, *Ziphius Sowerbii*, in Dingle Bay, Co. Kerry.

David Moore, Ph. D., has left a memory not less enduring in the records of the Academy's publications than in the hearts of all who knew him. His able management of the Botanical Gardens at Glasnevin for the last forty years as Director, has shown the possibility of uniting the keenest spirit of scientific investigation with a practical skill as invaluable as it is rare. In the early portion of his career, attached as Naturalist to the Ordnance Survey, his first important

work was a contribution to a Flora of Ireland, published in t Memoirs of the Survey; another work, under the name of *Cyb* *Hibernica*, giving the geographical distribution of Irish plants, w published by him in conjunction with A. G. More, F. L. S. later years, amid all the distractions of his daily duties, engaged as was in labours that have produced in the Glasnevin Gardens one the best stocked collections in Europe for its size, his studies to the special direction of investigations into Irish mosses and liverwor on which he contributed several Papers to the *Proceedings* of t Academy. The scholars of other countries were not slow to recogn the great worth of his researches, and the University of Leip bestowed on him a Degree, in token of its appreciation of the soun ness of his knowledge, and the value of his observations.

By the death of the Very Rev. C. W. Russell, D. D., President Maynooth College, Ireland has been deprived of one of her most r spected scholars. Born in 1812, in the County Down, and educat in Maynooth College, he subsequently held for many years the Ch of Ecclesiastical History in his College, of which he finally becam President in 1857. A man of singular refinement and courtesy, as w as of a clear and penetrative intellect, he could not fail to exercise remarkable sway over the minds of those with whom he came in co tact. His sympathies with Irish Archæology were manifested as f back as 1851, in an interesting essay on the subject of early Christi art in Ireland; but his first work of consequence was his Life of t celebrated linguist Cardinal Mezzofanti, published in 1858. Sin then many of his writings have attracted public notice, notably h editions of several volumes of the Calendars of State Papers r lating to Ireland. In 1869 he published, in the *Proceedings* of t Academy, the following Papers:—"On an Agreement in Iri (with fac-simile) between Gerald, first Earl of Kildare, and t Mac Rannalls," of the date of 1530; and "On the 'Duties up Irishmen' in the Kildare Rental-Book," in illustration of t Mac Rannall Agreement, in which Dr. Russell recognised evidence a system of irregular exaction on the part of the Geraldines from t Irish population outside the Pale. No more significant proof coul be given of the wide-spread appreciation of his merits as a schol and a writer than his appointment in 1869 to be a Member of th Royal Commission on Historical MSS.

Sir Thomas Larcom became a Member of the Academy so far back as 1833. Holding a seat for many years on the Council, he devoted much time to the furtherance of the aims of the Academy, and let slip no opportunity of advancing its interests. It was mainly through his means that the Academy attached to itself the services of men like O'Donovan, O'Curry, and Petrie, whose capacities he was one of the first to discover, and whose labours in the field of archæological research none could better appreciate, and few did more heartily sympathize with. His appointment to the charge of the Ordnance Survey was the signal of a new era in the history of the antiquities of Ireland; the measures adopted and carried out by him have laid the foundation for a thorough study of the topography of Ireland from the earliest times, based on the yet existing monuments scattered everywhere throughout the country. The results are garnered in the splendid set of the 149 volumes of the Ordnance Survey, including eleven volumes of drawings, which were presented to the Academy in 1860, by the Government of the time. The materials here brought together, on a plan originated by Sir Thomas Larcom himself, and successfully carried out under his superintendence, furnish a trustworthy and valuable store of information on almost every place of interest in Ireland; and it was mainly owing to his influence that the Academy is now in possession of the treasury of topographic lore thus collected. Here is not the place to speak of his administrative labours, but in all that relates to the history and antiquities of Ireland, the honour of initiating some of the most important advances that have been made belongs undoubtedly to Major-General Sir Thomas Larcom. At the close of his career, by his valuable bequest, he manifested at once his continued interest in Irish affairs, and his deep sense of the importance of the labours of this Academy.

The Report, to which was attached the following Appendix, was adopted:—

APPENDIX A.

PARLIAMENTARY GRANT FOR THE PREPARATION OF SCIENTIFIC RE

[*Vide* also Appendix B., Minutes of *Proceedings*, for 1875, page

From April 1874 to March 1880, upwards of sixty appl
were made to the Council for assistance of the above Grant o
a-year.

Of these, the following Grants have been recommended
Council, and approved by the Academy, and the amounts for
to the respective applicants :—

No.	Date.	Name and Subject.	
	1875.		
41	Feb. 15.	E. T. Hardman, on chemico-geological researches, . .	
42	,, ,,	W. H. Mackintosh, Researches on the Echinoidea, .	
43	,, ,,	G. Porte, on micro-photographic experiments, . . .	
44	Mar. 16.	Leith Adams, on exploration of caves of Shandon, . .	
45	,, ,,	Handsel Griffiths, on effect of certain drugs on the circulation, ...	
46	,, ,,	Reuben Harvey, Researches on staining re-agents, . .	
47	,, ,,	A. H. Church, Report on some arseniates and phosphates, ...	
48	June 24.	A. Carte, Investigating the bog of Ballybetagh, . .	
49	Nov. 19.	W. King, Researches into the jointing of rocks, . . .	
	1876.		
50	Mar. 20.	Rev. E. O'Meara, Further investigations into the Diatomaceæ, ...	3
51	,, ,,	Leith Adams, Report on Irish Pleistocene Mammals, .	1
52	,, ,,	Rev. S. Haughton, Report on the tidal constants of the Irish Sea, ...	5
53	,, ,,	L. Studdert, and A. Plunkett, on mineral waters of Mallow, ...	2
54	,, ,,	C. Bell, Investigations into Pyrrol, ...	2
55	Mar. 16.	E. Reynolds, Investigations into the atomic weight of glucinium, ...	4
56	,, ,,	E. P. Wright, Report on chytridia parasite on florideæ,	1
57	,, ,,	C. E. Burton, on the spectroscope, ...	
	1877.		
58	Mar. 16.	Rev. S. Haughton, Report on the tidal constants of the Irish Sea, ...	5
59	,, ,,	C. Bell, Further investigations into Pyrrol, ...	1
60	,, ,,	R. Ball, Towards the expenses of recording the observations of Jupiter's Satellites, ...	5
61	,, ,,	J. E. Reynolds, and Rev. S. Haughton, for experiments on the dynamical co-efficients of friction at low velocities between solids and fluids, ...	2

Date.	Name and Subject.	Amount of Award.		
1877.		£	s.	d.
Mar. 16.	Rev. J. H. Jellett, for experiments on the action of a galvanic current on a beam of polarized light, . .	25	0	0
,, ,,	E. P. Wright, towards the cost of drawings of some of the lower algæ, ...	40	0	0
1878.				
Mar. 16.	C. Tichborne, Researches into the general diffusion of fluorine in animal concretions, ...	25	0	0
,, ,,	E. T. Hardman, for apparatus and chemicals to enable him to continue his chemico-geological researches, .	25	0	0
,, ,,	A. G. More, for examination of the flora of the south and west of Ireland, ...	20	0	0
,, ,,	Leith Adams, towards the expense of collecting materials relating to the natural history of the Irish elk, . .	12	0	0
,, ,,	Rev. J. H. Jellett, for researches on the relation between light and electricity, ...	18	0	0
,, ,,	A. Macalister, for purchase of rare specimens to carry on embryological experiments, ...	30	0	0
Aug. 5.	W. H. Baily, for report on Cambrian and Silurian fossils,	40	0	0
1879.				
Jan. 13.	G. H. Kinahan, on studies on the constituents of granite,	10	0	0
,, ,,	E. W. Davy and C. A. Cameron, Researches into the compounds of Selenium, ...	30	0	0
Mar. 16.	E. W. Davy, Researches on the nitro-prussides, . .	21	8	0
,, ,,	E. P. Wright, Investigations into the structure of the vegetable cell and its nucleus, ...	50	0	0
,, ,,	J. E. Reynolds and Rev. S. Haughton, for microscopic slide sections of a large collection of Sandwich Island lavas, already analysed by Dr. Haughton, ...	20	0	0

The amount granted to No. 57 has been applied to the cost of con- uction, for the Academy, of a New Spectroscope, described in the *oceedings*, vol. i., series ii., Science, p. 208.

Nos. 45 and 50 have died.

Nos. 60 and 75 returned their Grants, not being able to follow out line of research intended.

Nos. 41, 42, 43, 44, 48, 51, 53, 54, 55, 56, 59, 61, 65, and 67, re forwarded either preliminary or final Reports.

Letters have been sent by the Secretary of the Academy and the retary of Council to each of the other recipients of Grants, Nos. 47, 49, 52, 58, 62, 63, 64, 66, 68, 69, 70, 71, 72, 73, 74, and sfactory answers respecting the progress of their researches have n received from all, except from Nos. 69 and 70, from whom no lies have been, as yet, received.

The President then declared the Ballot open for the electi
of Honorary Members.

Dr. Casey and Mr. Fitzgerald were nominated Scrutineers.

The votes of the Academy were taken on the following Grants:

£10 to Mr. A. T. Stewart for the Exploration of the Botany
the portion of the County of Fermanagh west of Lough Er
including what is called the Highlands of Fermanagh.

£20 to Dr. Reynolds and Rev. Dr. Haughton for Microscop
Slide Sections of a large collection of Sandwich Island Lavas, alrea
analysed by Dr. Haughton.

£30 16*s.* 6*d.* to Professor H. W. Mackintosh, for the structure
Echinoderms.

£25 to Mr. F. Hodges, for researches on the action of vari
bleaching agents.

£10 to Mr. Isaac Carroll, to explore the Botany of the district
the County of Cork lying to the westward of a line drawn fr
Skibbereen to Bantry.

£20 to Dr. Sigerson, for the construction of an electric apparat
for Physiological investigations.

£25 to Mr. Bertram C. Windele, for researches on the embryolo
of the Muscular System.

The Grants were adopted by the Academy.

The Scrutineers handed in their Report as to the election
Honorary Members, when the President declared the following du
elected:—

In the Department of Science.

Elias Loomis, Yale College, United States, America; O. C. Mar
Harvard College, United States, America; Oswald Heer, Zürich.

In the Department of Polite Literature and Antiquities.

Professor Fick, Göttingen.

The Scrutineers handed in their Report as to the election

President and Council, and the President declared the following duly elected :—

PRESIDENT.

SIR ROBERT KANE, LL.D., F.R.S., &c.

COUNCIL.

Committee of Science.

John Casey, LL.D., F.R.S., Professor of Mathematics, Catholic University of Ireland.

Thomas Hayden, M.D., F.K.Q.C.P.I., Professor of Physiology, Catholic University of Ireland.

Rev. J. H. Jellett, B.D., S.F.T.C.D.

Alexander Carte, M.D., F.L.S., Director, Museum of Science and Art, Dublin.

Robert S. Ball, LL.D., F.R.S., Professor of Astronomy, Dublin University, and Royal Astronomer for Ireland.

Rev. Samuel Haughton, M.D., F.R.S., F.T.C.D., Professor of Geology, Dublin University.

Edmund W. Davy, M.D., Professor of Medical Jurisprudence, Royal College of Surgeons, Ireland.

Joseph P. O'Reilly, C.E., Professor of Mineralogy, Royal College of Science, Dublin.

Benjamin Williamson, M.A., F.R.S., F.T.C.D.

George F. Fitzgerald, M.A., F.T.C.D.

Alexander Macalister, M.D., Professor of Anatomy, Dublin University.

Committee of Polite Literature and Antiquities.

John Kells Ingram, LL.D., F.T.C.D., Librarian of Trinity College, Dublin.

William J. O'Donnavan, LL.D.

Alexander G. Richey, LL.D., Q.C.

Very Rev. W. Reeves, D.D., Dean of Armagh.

Robert Atkinson, LL.D., Professor of Sanskrit, Dublin University.

Lord Talbot de Malahide, F.R.S.

Sir Samuel Ferguson, LL.D., Q.C.

J. T. Gilbert, F.S.A.

Rev. Maxwell H. Close, M.A.

John R. Garstin, LL.D., F.S.A.

The President appointed, under his hand and seal, the followin Vice-Presidents for the year ending March 16, 1881 :—

Alexander Richey, LL.D., Q.C.
Rev. Samuel Haughton, M.D., F.T.C.D.
John Kells Ingram, LL.D., F.T.C.D.
John Casey, LL.D.

The Ballot was then opened for the election of the Officer the Academy, and on the Report of the Scrutineers the Presid announced that the Officers of the Academy had been elected follows :—

TREASURER.—Rev. M. H. Close, M.A.
SECRETARY OF THE ACADEMY.—Robert S. Ball, LL.D.
SECRETARY OF THE COUNCIL.—Robert Atkinson, LL.D.
SECRETARY OF FOREIGN CORRESPONDENCE.—Joseph P. O'Reilly, c
LIBRARIAN.—John T. Gilbert, F.S.A.
CLERK OF THE ACADEMY.—Edward Clibborn, Esq.

Mr. John Ribton Garstin presented to the Academy a copy of th Church Bells of Devon, by the Rev. H. T. Ellacombe.

The thanks of the Academy were voted to the Donor.

The Academy then adjourned.

MONDAY EVENING, APRIL 12, 1880.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Before the ordinary business of the evening commenced, the President said that it was his duty to report to the Academy the death of Mr. Edward Clibborn, who had occupied for upwards of forty years the responsible position of Clerk to the Academy. During the whole period of Mr. Clibborn's services he was distinguished by the most zealous discharge of his duties, and by the intelligent interest which he took in every branch of the business of the Academy. Mr. Clibborn was possessed of varied and extensive literary and scientific information, which on many occasions enabled him to render his assistance specially useful to the officers of the Academy, for instance, in the early arrangements of the Museum of Antiquities, of which the Academy is so justly proud.

The President felt sure that the regret which he deeply felt at the loss of a gentleman with whom he had the pleasure of being associated for many years will be sincerely sympathised with by the Members of the Academy generally.

Professor J. P. O'Reilly, C.E., read a Paper "On the Correlation of the Lines of Faulting of the Palamon Coal-field District, Bengal Presidency, Northern India, with the neighbouring Coast-lines."

William Roberts read a Paper "On the Satellite of a Line meeting a Cubic."

G. H. Kinahan and W. H. Baily read a Paper—"Report (Part II.) on the Rocks of the Fintona and Curlew Mountain Districts."

A list of Donations was read, and the thanks of the Academy were voted to the Donors.

MONDAY EVENING, APRIL 26, 1880.

A. G. RICHEY, Q.C., LL.D., Vice-President, in the Cha

Messrs. G. H. and Gerrard Kinahan read a Paper
"Report on the Eurites, or Basic Felstones, of the Silurian

MONDAY EVENING, MAY 10, 1880.

A. G. RICHEY, Q.C., LL.D., Vice-President, in the Cha

Messrs. Kinahan and Ussher read a Report "On the Ex
of Ballynamintra Cave, Cappagh, near Dungarvan, by Messrs.
Ussher, and Adams."

William A. Mahony, M.D., was elected a Member of the

The Treasurer submitted the estimate for the current yea

The list of Donations was read, and the thanks of the
voted to the Donors.

The Secretary was requested to prepare a draft Address
Excellency Earl Cowper, on his being appointed to the office
Lieutenant of Ireland.

MONDAY EVENING, MAY 24, 1880.

A. G. RICHEY, Q.C., LL.D., Vice-President, in the Chair.

A. Macalister, M.D., read a Paper "On an Inscribed Cone, b
the name of Tirhakah, King of Egypt."

G. H. Kinahan read a Paper "On Inscribed Stones in the Co
of Wicklow and Wexford."

The following Donations were announced, and thanks voted to the)onors :—

A silver bank token, by Captain William Robinson.

Seven Papers by Keller "On Inscribed Stones in Switzerland," resented by Mr. George H. Kinahan.

A jade celt was exhibited by the Rev. Dr. M'Ilwaine.

The following Address was adopted :—

To HIS EXCELLENCY EARL COWPER, K.G., *Lord Lieutenant General and General Governor of Ireland.*

MAY IT PLEASE YOUR EXCELLENCY,

"We, the President and Members of the Royal Irish cademy, desire to offer to your Excellency our respectful congratu- tions on your arrival in Dublin as the Viceregent of Her Most racious Majesty the Queen.

"The Body which we represent was incorporated by Royal harter during the last century, for the purpose of promoting the udy of Science, Polite Literature, and Antiquities.

"At our Meetings Memoirs are read, containing original investiga- ons in science, discussions on questions of literature or antiquarian search. Many of these Memoirs are afterwards published, and dis- ibuted to other learned Bodies throughout the world, from whom e Academy receives in return reports of their transactions.

"To the Academy has also been entrusted the important function f administering the Fund for scientific research which is annually llocated for this purpose by the liberality of Parliament.

"Under our auspices, fac-simile editions of some important Irish ISS. in the possession of the Academy and of Trinity College, ublin, have been published, with a view of rendering their contents enerally accessible to Celtic scholars and comparative philologists. Ve would invite your Excellency's attention to the extensive Iuseum of Antiquities which has been brought together by the bours of the Academy. This collection is essentially national, as he great majority of the objects it contains have been discovered on rish soil, and it is illustrative of the ancient arts and civilization of he country.

Monday Evening, June 14, 188(

Sir Robert Kane, ll.d., f.r.s., President, i

The President announced that he and the Memb were received by His Excellency Earl Cowper,] Ireland, on the 7th inst.

The Address adopted at the last Meeting was dent, to which His Excellency made the following

"Pray accept my best thanks for your con; arrival here as Representative of Her Majesty the

"Your important duties, and the admirable ma are performed, are well known to me.

"The Papers read at your different Meetin editions of curious MSS., and your other publicat I have so cogent a reason for taking a deep i concerns Ireland, be of the greatest interest and a

"I look forward also, with the anticipation c entertainment, to making acquaintance with you of Antiquities, and to the means it will afford better knowledge of the ancient civilization of this

"If my office of Visitor to your Academy— assure you I feel both pride and pleasure in filli

Hardman, F.C.S., for making soundings in Lough Gill, with a view to throwing light on the geological formation of the locality."

The Secretary laid on the table a Memoir "On Cubic Transformations," by John Casey, LL.D., F.R.S., V.P., being the first number of the Cunningham Memoirs.

A list of Donations to the Library was read, and thanks voted to the Donors.

The President announced that, in consequence of his other avocations, Dr. Robert S. Ball found himself reluctantly compelled to resign the position of Secretary to the Academy; and that at its next Meeting the Academy will proceed to the election of a Secretary.

Several donations to the Museum were exhibited, in reference to some of which the following letter was read:—

"ENNISKILLEN, *June 5th*, 1880.

"SIR,

"I have been requested by the Earl of Enniskillen to forward for presentation to the Royal Irish Academy the following objects, which were recently discovered in a sepulchral mound situate at a place called Killicarney, not far from Belcoo:—

"1. A perfectly preserved vessel, composed of baked clay, containing calcined bones.

"2. Numerous portions of a second earthen vessel found in the same mound.

"3. A finely polished stone celt, which was found in the kist which contained the perfect urn.

"4. A small but beautifully formed knife or saw, composed of flint, which was found in the same kist.

"5. A rudely formed object of flint, found with the above-mentioned knife or saw.

"6. An object composed of bone, discovered with the flints.

"His Lordship wishes these objects to be presented, through himself, on the part of Loftus Tottenham, Esq., M. P., of Glenfarme Hall, near Belcoo.

"On my own part, I beg to present to the Academy a couple of human skulls and other remains which were found by myself in the

very curious and, I believe, prehistoric mound of Toam, near Bel
I have most carefully investigated the history of these finds, and I
drawn up a Paper upon the subject, which Paper, accompanied
numerous illustrations, is now in print, and will, I trust, very
appear in *The Journal of the Royal Historical and Archæological A
ciation of Ireland.* I may add that the skull which I have packed
box by itself will probably be found with the loss of some of
teeth. The teeth, however, will be found in the box with the sk
and may be re-inserted.

"A lucifer match-box which accompanies the bones cont
specimens of the charcoal which accompanied the interments.

"I have the honour to remain,

"Your obedient Servant,

"(Signed) W. F. Wakeman

"*To* The Secretary, *Royal Irish Academy.*"

The following object was also exhibited :—

Slab of micaceous schist, with cup markings, found at Balli
mark, near Ovoca, Co. Wicklow, presented by M. H. Jones, Esq.
Knocknamohill.

The thanks of the Academy were voted to the Donors.

Monday, June 28, 1880.

Sir Robert Kane, ll.d., f.r.s., President, in the Chair.

The President proposed the suspension of the standing orders,
there being no dissentient voice, the standing orders were decl
suspended.

Mr. Close (Treasurer) proposed——

"That Dr. Macalister, Professor of Anatomy and Chirurgery in
School of Physic in Ireland be elected Secretary of the Academ
the place vacant by the resignation of Dr. Robert S. Ball, F
Astronomer Royal of Ireland."

Dr. Macalister's nomination was seconded by Dr. Frazer.

The President declared the Ballot open for the election of a Secretary to the Academy.

The Secretary of the Council (Dr. Atkinson) read the recommendation of the Council that Mr. A. Edgar be appointed Clerk of the Academy in the place of the late Mr. Clibborn.

The President declared the Ballot open for the election of a Clerk of the Academy.

Sir Samuel Ferguson, LL.D., presented a Fasiculus of Prints from Photographs of Casts of Ogham Inscriptions, and read an abstract of an Introduction thereto.

Sir Samuel Ferguson, LL.D., read a Paper "On Sepulchral Cellæ."

Dr. F. A. Tarleton, F.T.C.D., read a Paper "On Chemical Equilibrium."

The following Papers were taken as read:—

Mr. Thomas Plunkett's, "On two Log Huts discovered in the Coalbog, Co. Fermanagh, twenty-one feet below the surface of the peat."

Professor J. Emerson Reynolds, M.D., F.R.S., "Reports on experiments on the comparative action of the Isomeric bodies Sulpho-Cyanate of Ammonium and Sulpho-Urea, on the growth of certain plants."

The Secretary read a Paper for Professor W. King, D.SC.: "Report on the Relation of Rock-jointing to Phenomena in Physical Geography and Physical Geology," Part I.

The Secretary read a Paper for Geo. Armstrong, C.E.: "On a discovery of Human Remains in the neighbourhood of Dundalk."

The Secretary laid on the table the first volume of the Irish Manuscript Quarto Series, Part I., "On the Calendar of Œngus," by Whitley Stokes, LL.D.

A list of Donations was read, and the thanks of the Academy were voted to the Donors.

The Scrutineers having reported, the President declared that John Patrick Gannon, Esq., Laragh, Co. Kildare, and Arthur H. Anglin, Esq., B.A., Cambridge, and M.A., Queen's University, Ireland, were duly elected Members of the Academy; that Professor Alexander Macalister was duly elected Secretary of the Academy; and that Alfred Edgar, Esq., was duly elected Clerk of the Academy.

The following Resolution was passed:—

"That the Academy, on the occasion of Dr. Ball's retiring the office of Secretary, desires to record its grateful sense of the nent services conferred on the Academy by Dr. Ball during his t of office.

MONDAY EVENING, NOVEMBER 18, 1880.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Mr. John Patrick Gannon, Laragh, Co. Kildare, signed the Roll, and was admitted a Member.

Sir Samuel Ferguson, LL.D., read a Paper "On the Doorway of the Round Tower of Kildare." [Vide *Proceedings*, vol. ii., ser. ii., part 3, Polite Literature and Antiquities.]

The Secretary presented, for Mr. W. R. Westropp Roberts, M.A., a Paper "On the Periods of the First Class of Hyper-elliptic Integrals." [Vide *Transactions*, Science, vol. xxviii., part 5.]

The Secretary read the list of Donations, and proposed, "that the thanks of the Academy be accorded to the Donors," which motion was carried.

TUESDAY EVENING, NOVEMBER 30, 1880.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

The President, having made a statement in reference to the document sent down from the Council, relative to the Scheme for the application of the Todd Memorial Fund, called upon the Secretary to read a copy of the Scheme approved by the Vice-Chancellor.

This Scheme will be found in an Appendix to the Report of Council for 1880-81.

Dr. Macalister read a Paper "On Notes on the Anatomy of two Negroes." [Vide *Proceedings*, vol. iii., ser. ii., Science, part 6.]

The Secretary read, for Mr. Philip Burton, a communication "On Halos and Anthelia."

The Secretary read the list of Donations to the Academy, and proposed, "that the thanks of the Academy be given to the donors," which was carried.

The Academy adjourned.

MONDAY EVENING, DECEMBER 13, 1880.

SIR SAMUEL FERGUSON, LL. D., in the Chair.

The Chairman declared the Ballot open, and asked Messrs. P and Kane to act as Scrutineers.

The Rev. J. H. Jellett detailed the results of experiments m by himself and George F. Fitzgerald, M.A., F.T.C.D., for the pur of ascertaining whether it be possible to detect any action a galvanic current on a beam of polarized light when transmit through air at the ordinary barometric pressure. Two grants been made some time ago by the Academy for the purpose of c ducting these experiments; but various causes of delay interve and the conclusive experiment was not made until Thursday last. details of the experiment are as follow:—

A beam of solar light was polarized by a Nicol's prism. It then transmitted through a brass tube, round which a double coi insulated copper wire passed. On emerging from the tube the b was analyzed by a Jellett's prism, capable of showing a deviation in the plane of polarization. A current obtained from a Gram machine, driven by a gas engine, 3½ h. p., was transmitted thro the coil, and the analyzing prism was adjusted so as to give a per equality of tint. The current was then reversed and the analy observed. By this method, as is easily seen, the change in the pl of polarization produced by the current would be doubled. But inequality of tints could be perceived. Hence it is to be inferred t a current such as that here described is incapable of producin deviation of 30″ in the plane of polarization of a transmitted be The dimensions of the several parts of the apparatus were the f lowing:—

Length of tube, ...	30·35 feet.
Thickness of wire, ...	0 inch ·096.
Length of wire, ...	1790 feet.
Number of coils, ...	5340.

The Secretary read, for the Rev. J. Pearson, a Paper "On Thr Years' Observations of the Tides at Liverpool (Fleetwood)." [Vi *Proceedings*, vol. iii., ser. ii., Science, part 6.]

Sir Samuel Ferguson requested A. G. Richey, Esq., V.P., to take the Chair, when he read "Notes on some Traces of Irish Influences at St. Gall and Bobbio."

The Ballot being closed, the Scrutineers reported Mr. T. Hughes Corry to be duly elected a Member.

The Secretary read the list of Donations, and proposed that the thanks of the Academy be accorded to the respective Donors.

MONDAY EVENING, JANUARY 10, 1881.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

The Ballot was declared open, and Professor Casey and Rev. Wm. Reynell were requested to act as Scrutineers.

The Rev. Samuel Haughton, M.D., D.C.L., LL.D., F.R.S., Fellow of Trinity College, and Professor of Geology in the University of Dublin, read a Memoir, entitled "New Researches in Sun-heat and Terrestrial Radiation."

PART I. contains the following results:—

1. Complete expressions for the Sun-heat, received daily and yearly, at any place, on the supposition that the earth has no atmosphere.

2. These expressions show that the Sun-heat received at any place is the same in the northern and southern hemispheres, when the latitudes are the same.

N.B.—This is true, whether the earth has an atmosphere or not.

3. Complete expressions for terrestrial radiation at any place; including a secular periodic variation of climate, depending on the first power of the eccentricity of the earth's orbit, and on the earth's perihelion longitude.

[Ordered for the *Transactions*.]

A Paper "On Researches in Annual Parallax" was read by Professor R. S. Ball, LL.D., F.R.S., Astronomer Royal. [Vide *Proceedings*, vol. iii., ser. ii., part 3.]

A Paper "On a Model of a Human Face from an Island o
Coast of New Guinea" was read by P. S. Abraham, B.SC. (L

The President announced that Mr. Robinson, Dr. Watts, an
Fletcher were duly elected Members of the Academy.

The Secretary read the list of Donations, and the thanks
Academy were accorded to the respective Donors.

MONDAY EVENING, JANUARY 24, 1881.

The REV. W. A. REYNELL, B.D., in the Chair.

Dr. Frazer proposed, and Dr. Fitzpatrick seconded, the foll
Resolution :—

"That the Academy desires to record its deep sense of th
sustained by itself and by the cause of science in the death
Humphrey Lloyd, Provost of Trinity College, who was for fort
years one of the most distinguished Members, and for five years
dent, of the Academy.

"His fame as an original investigator and successful cult
and promoter of Physical Science is of European extent; but it
be unsuitable to dwell thereon now when his recent loss is
prominently before our minds.

"Yet it may be allowable to say that our sorrow at his dep
is tempered with thankfulness that such a man has lived, an
pride at the lustre shed upon the Academy by his connexion
with. Those who knew him best and most intimately are the
whom his personal character and disposition were in highest estim

"The Academy hereby tenders to Mrs. Lloyd and the other s
ing relatives of the late Dr. Lloyd its sincere sympathy and cond
in their bereavement."

Dr. Frazer proposed, and Mr. H. Smith seconded, that the Ac
do now adjourn.

The Academy in consequence adjourned.

MONDAY EVENING, FEBRUARY 14, 1881.

The REV. PROFESSOR HAUGHTON, Vice-President, in the Chair.

The Secretary read the following Reply from Mrs. Lloyd to the President, acknowledging the Resolution passed by the Academy in recording their sense of the loss sustained by the Academy in the death of the late Provost of Trinity College :—

"PROVOST'S HOUSE,
"*February* 1, 1881.

"DEAR SIR ROBERT,

"I BEG you to express to the Council and Members of the Royal Irish Academy my grateful sense of their kindly feeling towards, and cordial appreciation of, my late husband shown in their Resolution of January 24th.

"I should sooner have made this acknowledgment, had I not been hindered by illness.

"Believe me,
"Very truly yours,
(Signed) "DORA LLOYD."

The Chairman declared the Ballot open, and requested Dr. Sigerson and Mr. Doherty to act as Scrutineers.

The Secretary read Notes on some Crania, sent to the College Museum by Dr. W. H. Hart, Colonial Surgeon, Sierra Leone.

The Secretary announced the discovery of a Kitchen Midden Heap of Shells, in the same locality as that from which the Human Remains were taken which formed the subject of Dr. Frazer's Paper in a late number of the Academy's *Proceedings* (vol. ii., ser. ii., p. 29, Polite Literature and Antiquities).

The shells formed a heap covering about twelve square feet, and six inches high, lying under cover of eighteen inches of surface soil. The shells were cockles, mussels, and periwinkles, mixed with broken bones of the ox and sheep, and lying on the boulder clay.

Dr. Ingram, V.P., here took the Chair, while the Rev. S. Haughton read the continuation of his "Researches (Part I.) on Sun-heat, with special regard to the Source of the Heat which gave to the Arctic Regions in Tertiary times the present Climate of Lombardy."

In this Memoir he gave a statement of the Middle Tertiary Cli of the Arctic Regions, from which he showed that at the latitu 80° N. the climate must have been :—

July Temperature 7 64°.1 F.
Mean Annual 7 47°.0 F. :

the present climate being—

July Temperature = 34°.0 F.
Mean Annual = 4°.5 F.

In order to convert the present climate of Lat. 80° N. into its Mi Tertiary Climate, we, therefore, require an addition of 30°.1 F. to July Temperature, and an addition of 22°.5 F. to the Mean An Temperature.

Dr. Haughton then explained his method of calculating, numeric the change of temperature in the Arctic Regions, north of 70° I which the Gulf Stream, the Kuro Scivo, and the Northern Mosamb were capable of producing; and showed that they fell short of what required by the testimony of the Tertiary Flora; and required the of sources of heat not furnished by Uniformitarian Theories.

Dr. Haughton having resumed the Chair, Mr. Barrington, by mission of the Academy, read his Paper "On the Flora of the Bla Islands."

The Chairman announced that Francis Davis Ward, J.P., and H Wm. Mackintosh, M.A., were duly elected as Members of the Acade

The Secretary laid on the table a Report by H. C. Hart, B.A., the Botany of the Galtee Mountains.

Dr. Macalister exhibited the impression of an Aboriginal H from a cave in New South Wales, presented to the Museum of Tri College by Dr. S. Knaggs, of Newcastle, N. S. W.; and a Necklace Human Teeth from the Soloman Islands, presented by Dr. Goode, R

The Secretary announced the list of Donations, and the thank the Academy were accorded to the respective Donors.

The Treasurer reported that the Council had recommended Academy to grant the sum of £20 to Messrs. Balkwill and Jos Wright for the examination of the *Foraminifera* of Dublin Bay, a £30 to Mr. Gerrard Kinahan, in aid of his Researches on the Chemi Impurities of River Waters, and proposed that the grants be co firmed, which motion was carried.

The Academy adjourned.

MONDAY EVENING, FEBRUARY 28, 1881.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Three new members, Messrs. Robinson, Fletcher, and Mackintosh, were admitted, having signed the Roll.

The Academy having given permission, Mr. Abraham proceeded to read his Paper, "On a Collection of Human Crania, and other objects of Ethnological interest from the West Coast of Africa."

Mr. W. J. Doherty read a Paper on "The Abbey of Fahan."

Dr. Macalister exhibited two skulls artificially deformed, from grave mounds in Hungary, near Pesth, resembling the Grafenegæ skull figured by Fitzinger.

Dr. Macalister also exhibited the mummied head of an ancient Peruvian from near Ancou.

The Secretary read the list of Donations to the Museum and Library, and the thanks of the Academy were accorded to the respective Donors.

The Academy adjourned.

WEDNESDAY EVENING, MARCH 16, 1881.

(Stated Meeting.)

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

The President declared the Ballot open for the election of Members of Council.

The Secretary of the Council brought up the

REPORT OF THE COUNCIL FOR THE YEAR 1880–1881.

Since the date of the last Report of the Council the following Parts of the *Transactions* have been published:—

Vol. xxviii.—*Science.*

Part 1. "On Chemical Equilibrium." By Francis Alexander Tarleton, LL.D.

Part 2. "On a New Genus and Species of Sponge with supposed Heteromorphic Zooids." By E. P. Wright, M.A., M.D.

Cunningham Memoirs.

No. 1. "On Cubic Transformations." By John Casey, F.R.S.

The following are laid on the table this evening:—

Transactions, vol. xxviii.—*Science.*

Part 3. "On Blodgettia confervoïdes of Harvey, forming a New Genus and Species of Fungi." By E. P. Wright, M.A., M.D.

Part 4. "On a New Genus and Species of Unicellular Algæ, living on the Filaments of Rhizoclonium Casparyi." By E. P. Wright, M.A., M.D.

Part 5. "On the Periods of the First Class of Hyper-elliptic Integrals." By William R. Westropp Roberts, M.A.

The following Parts of the *Transactions* are in the Press, and will be published immediately:—

Vol. xxvii.—*Polite Literature and Antiquities.*

Part 4. "Fasciculus of Prints from Photographs of Casts of Ogham Inscriptions." By Sir S. Ferguson, LL.D.

Part 5. "On Sepulchral Cellæ." By Sir S. Ferguson, LL.D.

Vol. xxviii.—*Science.*

Part 6. "New Researches in Sun Heat." By Rev. S. Haughton, F.R.S.

Of the *Proceedings*, part 4 of vol. iii. (Second Series), containing Papers on Science, was published in April, 1880; part 2 of vol. ii (Second Series), containing Papers on Polite Literature and Antiquities and part 5 of vol. iii. (Second Series), containing Papers on Science were published in December, 1880.

The contributors in the Department of Science are:—Rev. Dr Haughton; Dr. Davy; Rev. John H. Jellett; Dr. Ball; Dr. Tarleton Dr. Macalister; Professor J. P. O'Reilly; Professor J. Emerson Reynolds; Professor W. King; Rev. J. Pearson; Mr. G. H. Kinahan Mr. W. H. Baily; Mr. Philip Burton; Mr. W. R. Roberts; Mr. P S. Abraham; Mr. H. C. Hart; Mr. R. M. Barrington.

In the Department of Polite Literature and Antiquities:—Sir Samuel Ferguson; Dr. Macalister; Mr. George Armstrong; Mr. P S. Abraham; Mr. Thomas Plunkett; Mr. W. J. Doherty.

The following Grants in aid of the Preparation of Scientific Reports have been sanctioned by the Academy:—

£15 to Mr. E. Hardman for making Soundings in Lough Gill with a view of throwing light on the geological character of the district.

£20 to Messrs. F. P. Balkwill and Jos. Wright for an Examination of the *Foraminifera* of Dublin Bay.

£30 to Mr. G. A. Kinahan in aid of Researches on the Chemical Impurities of River Waters.

£50 to the Rev. Dr. Haughton to aid in completing his Researches on Sun Heat.

£10 to Dr. Hayes for Microphotography by Electric Light.

£15 to Mr. Barrington for the Botanical exploration of the islands of Lough Erne.

£10 to Mr. Stewart to complete the investigation of the Botany of the mountains of Fermanagh and Cavan.

And the following will be submitted to the Academy this evening for their sanction:—

£20 to Mr. H. C. Hart in aid of the exploration of the Botany of the Killarney mountains.

£25 6s. 6d. to Mr. A. G. More and Professor Alfred C. Haddon for Dredging in Dublin Bay.

After considerable delay the assent of the Court having been formally signified, the Council have taken the necessary steps to draw out the annual dividends upon the funds for the purpose of carrying into effect the objects of the Todd Memorial, so that the Todd Professor will deliver his lectures during the present year.

As anticipated in the last report, the *Book of Leinster* and the *Felire of Oengus* were published early in the session, and the *Book of Ballymote* is now in hands. The progress of art has made it possible to procure a perfectly trustworthy reproduction of this MS. by photo-lithography, so that in a few years we may hope to see all the great manuscripts in the hands of scholars. Sixty pages are nearly ready, and the work will be proceeded with as rapidly as possible: as the preparation of the introduction and analysis is going on *pari passu*, the publication may be expected almost immediately after the completion of the printing.

With respect to the *Annals of Ulster*, the Council regret to ha
state that the expectations expressed in the last Report of a comm
ment of the printing have not yet been fulfilled.

Numerous additions have been made within the past year t
collections in the Museum. They include many objects of conside
archæological interest—large double-conical beads of fine gold, of
doubted antiquity, lately found in the Co. Limerick, similar to t
already in the possession of the Academy; a unique fibula of si
an amulet, from Timoleague, Co. Cork, of admirable workmanshi
the form of a caterpillar, studded with numerous coloured ston
silver settings, known as the "conac," and long traditionally
nected in Ireland with the cure of the murrain in cattle; an an
canoe of oak, found in the bed of the river Suck after the recent re
able bogslip in Corbally townland; a knife of flint, with its ori
moss hafting, from the river Bann. Amongst the objects recentl
queathed to the Academy by the late Thomas M. Ray, Esq., of
city, are several implements of the bronze and stone periods,
various "finds" in Ireland; cabinets of coins of various count
medals commemorative of remarkable domestic and foreign event
silver, bronze, and other metals, some very curiously enamelled;
a singularly fine series of electrotyped medallions of the kings
emperors of France.

The Library has been repainted throughout; and the book-c
presses, and shelves therein, together with those in the Reading R
and Moore Library, numbered and lettered.

The following Ordinary Members have been elected since the
March, 1880:—

1. William A. Mahony, M.D.
2. John Patrick Gannon.
3. Arthur H. Anglin, M.A.
4. Thomas Hughes Corry, M.A.
5. John L. Robinson, C.E.
6. Robert George Watts, M.D.
7. Joseph Fletcher, F.C.S.
8. Francis Davis Ward, J.P.
9. Henry William Mackintosh, M.A.

We have lost by death within the year three Honorary Members—

In the Department of Science:—

1. Michel Chasles.
2. Carl Wilhelm Borchardt.

In the Department of Polite Literature and Antiquities:—

1. Thomas Carlyle.

And eight Ordinary Members:—

1. Robert Cryan, M.D., elected June 8, 1874.
2. James S. Eiffe, F.R.A.S., elected December 11, 1843.
3. Thomas Gallwey, J.P., elected June 11, 1866.
4. Anthony Hanagan, elected April 8, 1867.
5. Alfred Hudson, M.D., elected April 8, 1861.
6. Rev. H. Lloyd, D.D., elected February 27, 1832.
7. Michael H. Stapleton, M.D., elected April 13, 1846.
8. Sir Thomas Tobin, D.L., elected June 14, 1869.

One of these names demands notice here in an especial degree—the name of Humphrey Lloyd, late Provost of Trinity College, formerly President of the Royal Irish Academy.

Of illustrious lineage in the aristocracy of mind (for the name of his father, Bartholomew Lloyd, is inscribed on our rolls as that of one whom the Academy delighted to honour), Humphrey Lloyd has shed on our body the lustre of more brilliant scientific achievement, and earned for himself a wider renown.

His father was appointed Provost of Trinity College in the same year (1831) in which the late Provost was elected Professor of Natural Philosophy in the University. Thirty-six years after, in 1867, Humphrey Lloyd was admitted Provost, in which distinguished office he died, after a brief illness, in his eighty-first year, in the beginning of the present year (January 17, 1881), as universally regretted as he had been highly esteemed.

His work was nearly coextensive with his official career, for in the very year of his appointment as Professor, 1831, he published his *Treatise on Light and Vision;* and the third edition of his work *On the Wave Theory of Light*, together with his *Treatise on Magnetism*, were published in 1874. It was, in fact, to the problems of physical optics and terrestrial magnetism that his studies were specially

directed; but, in addition, his Papers on Meteorology contribute largely to the advance of that science, more particularly to th development of the Law of Storms.

It was by his remarkable investigations in physical optics th he first fixed the attention of the scientific world. In the Thi Report of the British Association (1833) Professor Lloyd furnish an account of the experiments by which he had established th existence of conical refraction in biaxial crystals, in conformit with the theoretical anticipations of Hamilton. It had been know since the beginning of the last century, that when a pencil of ligl is allowed to fall on certain crystals, it is in general divided in two rays. In Iceland spar—a uniaxial crystal—in which the ph nomenon of double refraction is conspicuous, it was found that one these rays obeys the ordinary law of refraction, and by a sagacio conjecture, based upon this fact, Huyghens obtained the law of th other, or "extraordinary" ray. Huyghens' law was for a long tin supposed to apply to all doubly refracting substances, till Brewst made known the existence of biaxial crystals, on which light may incident in either of two directions without being bifurcated—a ph nomenon which showed that Huyghens' law does not prevail in th crystals. Fresnel thereupon investigated the most general laws double refraction from the legitimate and perfectly general hypothe that the ether within a crystal acts under the same laws as a bo whose elasticity varies in different directions. From this hypothe he deduced the equation of the wave-surface, and showed that all t laws of biaxial crystals, known up to this time from the experimen of Brewster and Biot—both those laws which regard the direction the rays, and those which determine their polarization—were cons quences of this theory. He also showed that Huyghens' law a the other known phenomena of crystals with one optic axis follow as consequences of the particular case of his hypothesis where t elasticities are the same in directions parallel to one plane.

The geometrical form of Fresnel's wave-surface—a surface of tw sheets intersecting at four points—was investigated in minute det by M'Cullagh and Hamilton. In the course of this inquiry, Hamilt discovered that at each point of intersection a cone is tangent to t surface, and that where the outer sheet, after passing the point intersection, bends back, it has a tangent plane which touches

along a circular line of contact. To each of these geometrical properties an optical phenomenon should correspond, and it was an object of great scientific interest to ascertain whether these remarkable deductions from the wave-theory of light would be borne out by experiment, especially as the optical phenomena they predicted were unlike any known up to that time. The phenomena to be sought for by experiment were—1°. That a ray reaching the crystal in a direction pointed out by the theory, should be spread out within the crystal along the edges of a cone [*internal* conical refraction]; and, 2°. That a ray traversing the crystal in another indicated direction should on emergence be expanded into another cone [*external* conical refraction]. The difficulty of this investigation lay in the precision with which the requisite directions should be given to the rays, and the extreme care with which all other rays, even in closely neighbouring directions, should be excluded. Further, the limits within which the experiments could be made were rendered very narrow by the circumstance that in all known crystals the cone of intersection of the sheets of the wave-surface is very obtuse, and the circle of contact of the tangent plane is a circle subtending a very small angle at the centre of the surface. Professor Lloyd undertook the investigation, and at length, by great patience and wonderful skill, succeeded in making both the experiments, using slices of arragonite, a biaxial crystal. His success in this investigation has furnished us with a verification of the wave-theory of light, all the more significant as the deduction was very remote and the phenomena of a wholly novel character.

The xvii[th] volume of the *Transactions* of the Academy contains a full account of these researches, which at once lifted Professor Lloyd into the front rank of scientific experimentalists. In 1834 he furnished a Report to the British Association on "The Progress and Present State of Physical Optics," which is published in the Report of 1834.

In the field of magnetic research he was equally successful. This was indeed a heritage from his father, under whose auspices the Magnetic Observatory in Trinity College was founded. The Observatory was placed under the direction of Professor Lloyd, and was furnished with instruments devised by himself, and constructed by an eminent member of the Academy, the late Mr. Grubb.

Lloyd soon became recognized as one of the leading authorities

on this subject, and was associated with Sir J. Herschel and oth in the Committee appointed by the British Association to urge the Government of the day the importance of establishing magn observatories throughout Great Britain and in India. Their argumen backed by the influence of the Royal Society, wrought so effectu on the Government, that the measure was adopted. Such was universal confidence in Lloyd's skill and experience, that the p paration of the written instructions for the conduct of the observa ries was entrusted to him. How highly the British Association val his labours may be inferred from the fact that on their visit to Dub in 1857 he was selected by them as their President.

In 1877, the most important of his Papers, together with so valuable addresses delivered by him on various public occasions, w reprinted by the late Provost, and given to the world in a collec form—an example which it is highly desirable should be extensiv followed. A complete list of his Papers, published in our *Transacti* is here given.*

"An Attempt to facilitate Observations of Terrestrial Magnetism" (1833).

"On a New Case of Interference of the Rays of Light" (1834).

"On the mutual Action of Permanent Magnets, considered chiefly in refere to their best relative Position in an Observatory" (1839).

Supplement to a Paper "On the mutual Action of Permanent Magnets, c sidered chiefly in reference to their best relative position in an Ob vatory" (1841).

"On the Determination of the Intensity of the Earth's Magnetic Force in ab lute measure" (1843).

"Results of Observations made at the Magnetical Observatory of Dub during the years 1840–43" [1st Series—Magnetical Declination] (18

"On the Mean Results of Observations [Magnetical and Meteorological (1848).

"Notes on the Meteorology of Ireland, deduced from the Observations made the year 1851, under the Direction of the Royal Irish Academy" (18

"On the Determination of the Intensity of the Earth's Magnetic Force absolute measure, by means of the Dip-Circle" (1858).

"On the Light reflected and transmitted by Thin Plates" (1859).

"On Earth-Currents and their Connexion with the Diurnal Changes of Horizontal Magnetic Needle" (1861).

"Attempt to deduce the General Laws of the Variations of Temperature at Earth's Surface from those of Solar and Terrestrial Radiation" (1878)

* Numerous Papers on the above and kindred subjects are published in *Proceedings* of the Academy.

These labours were naturally not unregarded by the Academy, who awarded him the Cunningham Medal in 1862, having previously, in 1846, bestowed upon him the highest honour in their power by electing him their President.

In 1874 there was conferred on him by the Emperor of Germany the order "Pour le Mérite." No more significant proof could be given that the respect in which he was held in his own country was no mere local partiality, but was due to the intrinsic worth of the man.

But high as he thus stood in men's estimation for his scientific merits, he stood, if possible, yet higher in their thoughts as a man deserving implicit trust. Till the close of his life his advice was eagerly sought, for his counsel was as sagacious as his sympathies were large; and his decisions, calmly and quietly given, were accompanied by a charm of earnestness and self-abnegation that compelled the esteem and affection of all men, even of those who differed from him in opinion. To this charm of manner and singleness of purpose was added a singular receptivity of new thought; never warped by old methods, nor trammelled by routine, he was equally ready to assimilate new truths, and to lend encouragement to every honest worker. With him success was no measure of effort, and his praise was as ungrudging as it was sincere. Judging others by his own earnestness and candour, he was repaid by the profound respect of all with whom he had to deal. To no man did fame ever come more unsought, and no man was ever less spoiled by fame. Rarely has such a warm sympathy been felt so continuously: the honours that his labours and character could not fail to secure him after death seem to have attended him throughout his whole life:

quod dedistis
viventi decus atque sentienti
rari post cineres habent.

The Report of the Council was adopted.

The following Grants were approved of by the Academy:—

£25 6*s*. 6*d*. to Mr. A. G. More and Professor Haddon for Dredging in Dublin Bay.

£20 to Mr. H. C. Hart in aid of the Exploration of the Botany of the Killarney mountains.

The Secretary announced the reception of the specimens bequeat to the Academy by the late Mr. Thomas Matthew Ray, and moved

"That the Academy hereby records its high appreciation of liberal and patriotic spirit which moved the late Mr. Thomas Matt Ray to leave his valuable collection of objects of national and gen interest to the Royal Irish Academy. Also that the Academy ten its best thanks to Miss Mary Ray and Mr. Thomas M. Ray, the e cutors and children of the testator, for the promptitude and ac with which they carried out his intentions towards the Academy."

The Rev. M. H. Close seconded the Resolution, which was carr

The Ballot being closed, on the Scrutineers' report the Vice-Pr dent declared the following duly elected :—

PRESIDENT.

SIR ROBERT KANE, LL.D., F.R.S., &c.

COUNCIL.

Committee of Science.

Rev. J. H. Jellett, D.D., Provost, T.C.D.
Alexander Carte, M.D., F.L.S.
Robert S. Ball, LL.D., F.R.S.
Rev. S. Haughton, M.D., S.F.T.C.D., F.R.S.
E. W. Davy, M.A., M.D.
J. P. O'Reilly, C.E.
George F. Fitzgerald, M.A., F.T.C.D.
Alexander Macalister, M.D.
John Casey, LL.D., F.R.S.
F. A. Tarleton, M.A., F.T.C.D.
George Sigerson, M.D.

Committee of Polite Literature and Antiquities (and Museum).

A. G. Richey, LL.D., Q.C.
Very Rev. W. Reeves, D.D.
Robert Atkinson, LL.D.
Lord Talbot de Malahide, F.R.S.
Sir Samuel Ferguson, LL.D., Q.C.
John T. Gilbert, F.S.A.
Rev. M. H. Close, M.A.

John R. Garstin, M.A., LL.D.
John Kells Ingram, LL.D., F.T.C.D.
William Frazer, F.R.C.S.I.

The President, Sir Robert Kane, nominated the following under his hand and seal as Vice-Presidents for the year :—

Rev. Samuel Haughton, M.D., F.R.S., S.F.T.C.D.
John Kells Ingram, LL.D.
John Casey, LL.D., F.R.S.
Sir Samuel Ferguson, LL.D.

The Ballot was opened for the Office-bearers. Messrs. Porte and Archer were appointed Scrutineers. On the close of the Ballot the Chairman announced that the following were elected :—

TREASURER.—Rev. Maxwell H. Close, M.A.
SECRETARY.—Alexander Macalister, M.D.
SECRETARY OF THE COUNCIL.—Robert Atkinson, LL.D.
SECRETARY OF FOREIGN CORRESPONDENCE.—Joseph P. O'Reilly, C.E.
LIBRARIAN.—John T. Gilbert, F.S.A.
CLERK OF THE ACADEMY.—Alfred Edgar, B.A.

The Academy then adjourned.

APPENDIX A.

Cunningham Fund, Royal Irish Academy.

Order of the Master of the Rolls, dated December 18, 1878.

Scheme for the Regulation and Management of the Beques £1000, made by the Will of Timothy Cunningham, formerl Gray's Inn in the county of Middlesex, dated 10th June, 1 to the Royal Irish Academy, for the purpose of being dispos in such Premiums as the said Academy should think proper, for Improvement of Natural Knowledge and other objects of their I tution, and of the Stocks and Funds now representing such Beque

1st. The said Bequest, with the interest and dividends w have from time to time been added thereto, amounting to the of £2618 9*s.* 5*d.*, Government New Three per cent. Stocks, standing in the Books of the Governor and Company of the B of Ireland, in the name of the Royal Irish Academy, after paym thereout of the costs of the proceedings in this matter and o herein, shall henceforward constitute and be called "The C ningham Bequest Fund."

The Annual Income of said Fund shall be applied as follows

1st. In Premiums of an honorary character, such as Medals other marks of distinction of a like nature, to be awarded from t to time by the Council for the time being of the Royal Irish A demy to persons rendering (in the opinion of the said Council) e nent services in the improvement of knowledge in Science, Po Literature, or Antiquities.

2nd. In pecuniary Premiums to be awarded from time to t by the said Council to the authors of the best Essays (by the Council considered worthy of such Premiums) upon subjects c nected with Science, Polite Literature, or Antiquities; such s jects to be proposed by the said Council when, and in such man as, they shall think fit.

3rd. In the publication, under the title of "Cunningham Prize Memoirs," of such Papers in Science, Polite Literature, or Antiquities, communicated to the Academy, as in the opinion of the said Council may possess eminent merit.

4th. If, after providing for the several purposes aforesaid, any balance of the said Annual Income shall remain undisposed of, the same shall be applied for the purpose of increasing future pecuniary Premiums to be awarded under Clause 2, as the said Council shall think most expedient.

APPENDIX B.

ROYAL IRISH ACADEMY'S TODD PROFESSORSHIP OF THE CELTIC LANGUAGES.

Scheme for the Regulation of the above-named Professorship, as approved and adopted by the Vice-Chancellor's Order, August 2, 1880.

1. The Fund from time to time representing the "Todd Memorial Fund" shall be held by the Royal Irish Academy, subject to the trusts of this scheme.

2. The Council of the Royal Irish Academy shall be at liberty to elect a Professor, to be called "The Academy's Todd Professor of the Celtic Languages," hereinafter called the Todd Professor.

3. Such Todd Professor shall be appointed triennially.

4. The outgoing Professor shall be re-eligible.

5. The duties of the Professor shall consist in delivering before the Academy a series or course of lectures annually during the session; such series or course to consist of such number of lectures, not being less than four in each session, as the Council of the Royal Irish Academy shall from to time appoint.

6. The subject of such annual series or course of lectures shall be the Celtic Languages.

7. The Royal Irish Academy may from time to time make suc laws and regulations (not inconsistent with the provisions hereinb or hereinafter contained) for regulating the mode of election o Todd Professor, the subjects of the lectures to be comprised in course, the time and place of delivery of all such lectures, the p cation of any such lecture, the preservation of the manuscript o materials used in the preparation of any such lectures, or general relation to the functions and duties of the Todd Professor, as t Royal Irish Academy shall seem expedient.

8. The stipend of the Todd Professor shall be £40 per annu such greater sum as the Royal Irish Academy shall from time to appoint.

9. The income of the "Todd Memorial Fund," so far as the shall extend, shall be applied in payment of the said annual stip

MONDAY EVENING, DECEMBER 12, 1881.

SIR SAMUEL FERGUSON, Q.C., LL.D., Vice-President, in the Chair.

Donations were announced, and the thanks of the Academy voted to the Donors.

The Secretary of Council read the proposed regulations for the Academy's Todd Professorship of the Celtic languages, and explained at length the principle on which the Council had acted in drawing up the proposed regulations.

The regulations were unanimously adopted.

The Secretary laid on the table part 7 of vol. xxviii. of the *Transactions* of the Academy—"Extension of the Theory of Screws to the Dynamics of any Material System." By R. S. Ball, LL.D., F.R.S.

MONDAY EVENING, JANUARY 23, 1882.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Mr. T. N. Deane read a Paper "On the Remains of Quin Abbey, Co. Clare."

By permission of the Academy Mr. Davison read a Paper "On the Alterations in Structure in Bones consequent on Fracture."

Dr. Frazer exhibited a wax model made by Mossop of Lord Charlemont; also two letters bearing on the early history of the Academy.

The following Grants, recommended by Council, were confirmed :—

£15 to T. H. Corry, M.A., for a Botanical Survey of Ben Bulben.

£20 to John L. E. Dreyer, F.R.A.S., for Calculations to determine the exact value of the Constant of Precession.

£30 to Rev. W. Green, towards exploring the New Zealand Glaciers.

£25 to W. F. De V. Kane, M.A., and R. Sinclair, for examining the Entomological Fauna of the wooded districts of Ulster.

The Secretary read the list of donations to the Academy.

The thanks of the Academy were voted to the Donors.

MONDAY EVENING, FEBRUARY 13, 1882.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Dr. Frazer read a Paper "On some Discoveries made during t Excavations of the Ailesbury-road Mound."

Sir Samuel Ferguson, LL.D., read a Paper on "The Legend of t Death of Dathi."

The following were elected Members of the Academy:—Mr. MacCarthy Collins; Rev. Michael Comerford; Mr. W. Sidney Cox, c. and Mr. Alexander M'Henry.

The following Grants, recommended by Council, were confirmed:

£20 to Professor Mackintosh, to aid in exploring the Zoophytes the Irish Coast.

£15 to A. G. More, to aid in exploring the Botany of St. Kilda.

The Secretary announced the donations to the Academy, and a vo of thanks was passed to the respective Donors.

Mr. Robert Macalister, LL.B., was declared elected Clerk of t Academy.

MONDAY EVENING, FEBRUARY 27, 1882.

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Mr. Alexander M'Henry signed the Roll, and was admitted Member of the Academy.

The Rev. Dr. Haughton, F.R.S., read his Paper on "Atriptothalas Curves and Surfaces."

Dr. Tarleton, F.T.C.D., read a Paper "On some Deductions fr Professor M'Cullagh's Lectures on Rotation, and a slight Error whi appears to exist in them."

The Secretary laid on the table the following Reports:—

Professor A. H. Church, M.A. (Oxon.)—"On the Native Phosphates of Aluminium."

Messrs. Joseph Wright and J. P. Balkwill—"On the recent Foraminifera of Dublin and Wicklow."

Mr. S. A. Stewart—"On the Botany of Fermanagh."

The Secretary read, for Lord Talbot de Malahide, a Note "On an Inscription at Algiers."

The Secretary read the list of donations, and the thanks of the Academy were accorded to the respective Donors.

THURSDAY EVENING, MARCH 16, 1882 (Eve of St. Patrick's Day).

(Stated Meeting.)

SIR ROBERT KANE, LL.D., F.R.S., President, in the Chair.

Mr. Francis Davis Ward signed the Roll, and was admitted a Member of the Academy.

The President stated that at this Meeting the period of five years of his Presidency had expired, and that the time had come for the choosing of a new President.

Rev. Dr. Haughton proposed, and Mr. Justice O'Hagan seconded:—

"That Sir Samuel Ferguson be nominated to the Presidential Chair."

The President declared the Ballot open, and nominated Dr. Frazer and Mr. Porte Scrutineers of the Ballot for President and Council, and Professor O'Reilly and Rev. Mr. Reynell Scrutineers of the Ballot for Honorary Members.

The Secretary of Council read the Report for the past year, which was adopted.

REPORT OF THE COUNCIL FOR THE YEAR 1881–1882.

Since the date of the last Report of the Council the follow Parts of the *Transactions* have been published:—

Vol. xxviii.—*Science.*

Part 6. "New Researches on Sun-heat and Terrestrial Radiati and on Geological Climates." By Rev. Dr. Haughton, F.R.S.

Part 7. "Extension of the Theory of Screws to the Dynamics any Material System." By Robert S. Ball, LL.D., F.R.S.

Vol. xxvii.—*Polite Literature and Antiquities.*

Part 4. "Fasciculus of Prints from Photographs of Casts of Ogh Inscriptions." By Sir Samuel Ferguson, LL.D.

The following Parts of the *Transactions* are in the Press and w be published immediately:—

Vol. xxviii.—*Science.*

Part 8. "On some hitherto undescribed Compounds of Selenium By Charles A. Cameron, M.D., and Edmund W. Davy, M.D.

Part 9. "On the Dynamics of a Rigid System Moving in Non-E clidian Space." By Robert S. Ball, LL.D., F.R.S.

Of the *Proceedings*, part 6 of vol. iii. (Second Series), containi Papers on Science, was published in April, 1881; part 3 of vol. (Second Series), containing Papers on Polite Literature and Antiqu ties, and part 7 of vol. iii. (Second Series), containing Papers Science, were published in December, 1881.

The contributors in the Department of Science are:—Dr. Bal Drs. Davy and Cameron; Dr. Tarleton; Dr. Haughton; Dr. Daviso Professor O'Reilly; Professor Church; Mr. J. F. Knott; Mr. Hodges; Mr. G. A. Kinahan; Mr. E. T. Hardman; Mr. B. C. Windl Mr. W. R. Roberts; Messrs. J. Wright and F. P. Balkwill; Mr. S. Stewart.

In the Department of Polite Literature and Antiquities:—Lo Talbot de Malahide; Dr. Frazer; Dr. Macalister; Sir Samuel Fe guson; Mr. T. N. Deane; Mr. E. T. Hardman; Mr. W. J. Knowle Rev. T. Olden.

The following Grants in aid of the Preparation of Scientific Reports have been sanctioned by the Academy :—

£20 to Dr. Davy for further Researches on the Organic Nitro-prussides.

£15 to Mr. T. H. Corry for an Examination of the Botany of Ben Bulben.

£20 to Mr. J. L. E. Dreyer for Calculations to determine the exact Value of the Constant of Precession.

£30 to the Rev. W. Green towards Exploring the New Zealand Glaciers.

£25 to Mr. W. F. De Vismes Kane for an Examination of the Entomological Fauna of the wooded districts of Ulster.

And the following will be submitted to the Academy this evening for their sanction :—

£25 to Mr. H. C. Hart for a Botanical Exploration of the Mountain Ranges of Ireland.

£15 to Mr. R. M. Barrington to complete his Botanical Exploration of the Shores and Islands of Lough Erne.

£15 to Mr. S. A. Stewart for a Botanical Exploration of Rathlin.

£17 10*s*. 11*d*. (in addition to £30 already voted) to Rev. W. Green towards Exploring the New Zealand Glaciers.

The difficulties that retarded the delivery of the lectures of the Todd Professor having been removed, the Council believe that the lectures will be commenced before the close of the present session.

The Council have authorized the printing of the first volume of the *Annals of Ulster*. The Academy will remember that the cost of the production of the work will be defrayed directly by the Government, and will not be a charge on the funds of the Academy.

The preparation of the *Book of Ballymote* is being steadily proceeded with, upwards of two hundred pages of the MS. having been photo-lithographed, and the Council have reason to anticipate that before the end of the year one-half of the whole work will be completed.

The Museum has received during the past year large and valuable additions, comprising the collection made by Mr. William Perry, together with several minor collections, and a donation from Trinity

College of various objects of considerable antiquarian importan
These acquisitions include: — lunulæ, double conical beads, rin
fibulæ, fragments of torques, and bracelets—all of gold; silver s
bronze seals; finger and signet-rings and crosiers; bronze trumpe
crotals; pins and spurs; armlets; weapons and tools; stone imp
ments and moulds; glass and amber beads; sepulchral urns of cla
an ancient boat of oak, found near Baron's Court, Co. Tyrone;
amulet, found near Doneraile, Co. Cork, in 1834, similar in charact
and material to the "Conac" purchased some time ago by the Ac
demy; and a large quadrangular bell of gold bronze, of singular
fine workmanship, and in perfect preservation, said to have been fou
in Lough Lene, Co. Westmeath.

In the Strong-room additional accommodation for the deposit
numerous objects of value has been obtained by attaching a series
glazed drawers to the bases of the projecting desk-cases.

The first edition of the "Brief Handbook to the Museum" havi
been exhausted, a second and carefully revised edition has been pu
lished, in which are noted all changes recently made in the dispositi
of objects in the collection.

In the Academy House several important repairs have be
effected, and its exterior, together with that of the Reading-room a
Library buildings, thoroughly repainted.

In the Library a considerable amount of work has been done
the way of internal arrangements and towards completing the ca
logues and registration, more especially in connexion with the Halid
collection.

The following Ordinary Members have been elected since the 16
March, 1881:—

1. Francis John Boxwell Quinlan, M.D.
2. Rev. Daniel Davies Jeremy, M.A.
3. J. D. Hillis, M.D.
4. Daniel J. Freeman, M.R.I.A.I.
5. Rev. Francis Le Poer M'Clintock, M.A.
6. Charles Mac Carthy Collins.
7. Rev. Michael Comerford, P.P.
8. William Sidney Cox, C.E.
9. Alexander M'Henry.

We have lost by death within the year three Honorary Members—

In the Department of Science :—

1. Wilhelm Philipp Schimper.

In the Department of Polite Literature and Antiquities :—

2. Ferdinand Keller.
3. Maximilien Paul Emile Littré.

And twelve Ordinary Members :—

1. Philip Bevan, M.D., elected April 13, 1846.
2. Stewart Blacker, J.P., elected January 9, 1843.
3. Alexander Carte, M.D., elected February 12, 1855.
4. Leonard Dobbin, elected January 11, 1847.
5. Reuben Joshua Harvey, M.D., elected December 14, 1874.
6. Thomas Hayden, F.K.Q.C.P.I., elected August 24, 1857.
7. James Joseph Mac Carthy, R.H.A., elected April 11, 1853.
8. Robert Mallet, F.R.S., elected October 22, 1832.
9. Rev. Thomas Romney Robinson, D.D., F.R.S., elected February 14, 1816.
10. Colonel Crofton M. Vandeleur, D.L., elected May 26, 1834.
11. William H. Warren, M.D., elected June 23, 1872.
12. Edward Wright, LL.D., elected November 12, 1855.

It will thus be seen that the Academy has had serious losses during the present year, including two former Members of Council, and a President whose name stood among the foremost in the world of science.

In Alexander Carte, M.A., M.D., F.R.C.S.I., F.L.S., who died September 25th, 1881, the Academy has lost a respected and valued Member of its Council, and Science an earnest and faithful investigator. Dr. Carte commenced his scientific career as Curator of the Museum of the Royal College of Surgeons in Dublin. In 1851 he was appointed by the Royal Dublin Society to the charge of their Natural History Museum. At this period the Museum was lodged in a few rooms in Leinster House, on the Library floor, and, excepting its Mineral Collection, contained but few specimens of value. The great increase of the collections, as they now exist, in their present excellent arrangement, is due to the labour and energy of Dr. Carte, who, on the transference

of the Museum to the Science and Art Department, held the post Director till his death in September, 1881, his services thus extendi over thirty years. His assiduity in performing the duties entailed him in that office was not more remarkable than his care and skill a naturalist. His Paper in the *Philosophical Transactions* on the a tomy of *Balænoptera rostrata*, written in conjunction with Profes Macalister, the present Secretary of the Academy, is probably t best known of his contributions to Biological Science. To t *Proceedings* of the Academy he contributed, in conjunction with M R. J. Moss, M.R.I.A., a Report on the Animal Remains found in t Bog of Ballybetagh, near Dublin; and to the *Journal* of the Roy Dublin Society, papers on the Extinct Cave Animals of Ireland. the surgical profession, Dr. Carte will be remembered as the ingeni inventor of an elastic compress for aneurism.

Another valued Member of Council, and former Vice-President the Academy, has been lost to the Academy, in Dr. Thomas Hayde Dr. Hayden was appointed in 1854 to the Chair of Anatomy a Physiology in the Faculty of Medicine of the Catholic Universit which post he continued to hold until his death. In 1866 Dr. Hayd read before the Academy a Paper on "The Physiology of the Protrusi of the Tongue;" and, in 1871, a Paper discussing the effects of "T Respiration of Compressed Air." His attention subsequently was mo devoted to pathological than to physiological studies, and the result his researches in this direction became manifest, in 1875, in the pub cation of his work on "Diseases of the Heart and Aorta."

Reuben J. Harvey (son of Joshua R. Harvey, M.D., Professor Midwifery in Queen's College, Cork), was born in 1845, and educat in Trinity College, Dublin, where he took high mathematical hono graduating as Gold Medallist and Senior Moderator in Mathemati Having studied Medicine in Trinity College, where he took the fi Medical Scholarship (1868), he proceeded to his M.B. degree in 187 and subsequently, after studying at Würzburg, he became Demo strator of Anatomy in the Dublin University Medical School. 1872 he was made Lecturer in Physiology in the Carmichael Medic School. He was the author of several Papers on Physiology, one which "On the Intertubular Tissue of the Mammalian Testis," w be found in our *Transactions*, vol. xxvi., *Science*, part 2.

Robert Mallet, M.A., M. ENG., PH. D., F.R.S., M.I.C.E., F.G.S., and Honorary and Corresponding Member of various foreign societies, was born June 3, 1810, and died November 5, 1881. He was co-partner with his father, Mr. John Mallet, in the Victoria Foundry and Engineering Works, Dublin. Even from his boyhood he displayed a great interest in physical science, and when he became and continued to be actively engaged in the practice of his profession of civil engineer, he never remitted his attention to the more purely scientific consideration and investigation of the physical agencies and principles with which he was brought into contact. He entered Trinity College in 1826, and graduated in Arts in 1830. He was elected Member of the Academy in 1832, and made his first contribution to the Academy's *Transactions* in 1837. He became Member of the Institution of Civil Engineers in Ireland in 1836; and contributed numerous technical Papers to the *Transactions* of the Institution, of which he was made President in the years 1866–1867. The first of his important Papers on Physical Geology was presented in 1838 to the Geological Society of Dublin, the Presidency of which he held in the years 1847–1848, and in whose Journal he published many geological Papers. In 1839 he was elected Associate, and in 1842 Member, of the Institution of Civil Engineers of England (to whose *Transactions* he contributed various Papers); he was awarded by that Body, in 1841, a silver medal and premium for a communication on the Corrosion of Cast and Wrought Iron in Water, and in 1859 the Telford Medal for his investigation of the Co-efficients of Elasticity and Rupture in Wrought Iron. He was elected Fellow of the Royal Society of London in 1854, and of the Geological Society of London in 1859, and sat on the Council of both societies.

We cannot here do more than merely allude to the many important engineering works carried out by him, and the numerous inventions due to him, especially in the construction of artillery, his numerous Papers on which subject must not be passed over without reference. The department of physical geology to which Mallet more especially directed his attention was that of the phenomena and theory of earthquakes and volcanic action, for the discussion of which his training and practice as an engineer rendered him peculiarly well qualified. It is in connexion with this that his name will be principally remembered by men of science. The first of his Papers

gating the proper motions of the stars, and for the same reason it w continue to be of permanent value. Afterwards the mural circle w furnished with a new telescope, having a seven-inch object-glass, a chronograph was obtained from Knoblich, of Altona, and with th 1000 of Lalande's stars were re-observed, three or four times each, the years 1868–1876, and the results published in the *Transaction* the Royal Dublin Society, 1879.

Besides the astronomical Papers contributed by Dr. Robinson the *Transactions* (see appended list) and to the *Proceedings* of Academy, he has written various others in the *Transactions* and in *Proceedings* of the Royal Society, in the *Memoirs* and in the *Mont Notices* of the Royal Astronomical Society, and in the *Reports* of British Association.

During his long, active, and distinguished scientific career, Robinson made a great number of communications to differ societies on subjects pertaining to various branches of physics. would be impossible to give, within our present limits, even a b general sketch of the results of his labours. We must content selves with referring more particularly to his widely known much used invention, the Cup Anemometer, and to his investigati of its principles.

The essential parts of this instrument were devised by him in 18 and subsequent improvements made until it was completed in 18 in which year it was described by him before the British Associatio Southampton. In 1850 he read before the Academy a Paper th ject of which was to approximate to the theory of the instrument. 1874 there appeared a Memoir by M. Dohrandt of the St. Petersb Meteorological Observatory, describing an elaborate series of exp ments which he had made to determine the relation between velocity of the rotation of the Cup Anemometer and that of the w Dr. Robinson's attention being thus drawn again to the subject, read to the Academy in 1875 a Paper, which appears in the *Proceedi* "On the Theory of the Cup Anemometer and the Determination of Constants." In this he gave a criticism of Dohrandt's experim and suggestions for the removal of some objections to which t seemed to be open, with proposals for other experiments whic hoped he might afterwards carry out. This he soon had a favour opportunity of doing, with apparatus constructed by Mr. How

Transactions, "On the Construction of Furnaces for High Heats," was made in 1818. His "System of Mechanics" was published in Dublin in 1820.

In the year 1824 Robinson was appointed Director of the Armagh Observatory, which had been founded by the munificence of Primate Robinson in 1793. Owing to the death of the founder before complete arrangements were made, the Observatory was but indifferently furnished with instruments until 1827, when a transit instrument, and a mural circle having a telescope of 3·8 inches clear aperture were set up, the gifts of the then Archbishop of Armagh, Lord John George Beresford. Under the efficient direction of Dr. Robinson the results of this liberality were soon manifest in the publication of three parts of the "Armagh Observations" for 1828–30 (4to, Dublin). In 1859 was published in 8vo, in Dublin, with the aid of a Government Grant, on the recommendation of the Royal Society of London, his work entitled, "Places of 5345 Stars observed from 1828 to 1854 at the Armagh Observatory." The stars were principally Bradley's stars, excepting the larger ones (of which special observations were made at Greenwich), and those beyond 116° N.P.D. With very few exceptions the observations with the transit instrument down to March, 1837, and those with the mural circle down to 1849, were made by the Director himself. In the introduction to the volume are given details respecting the instruments and methods of observation, that astronomers may be able to estimate for themselves the degree of confidence which they can accord to the results. The labour involved in the making of so large a number of observations (several for each star), and in the subsequent reduction of the observations, was very great. It was more especially for this Catalogue that the Royal Medal of the Royal Society of London was awarded to Dr. Robinson in December, 1862.

This Catalogue has been in very extensive use; it has been employed in combination with others in the determination of the positions of moon-culminating stars for the "Nautical Almanac." Oom of Pulkova made a systematic comparison between it and Argelander's "Åbo Catalogue" (*Astron. Nachr.*, No. 1408). From the great number of stars contained in the Armagh Catalogue, of whose places we possess few or no recorded observations made elsewhere during the years 1830 to 1850, it was specially prized by Argelander for investi-

Committee of Science.

Robert S. Ball, LL.D., F.R.S.
Rev. Samuel Haughton, M.D., F.R.S., S.F.T.
Edmund W. Davy, M.A., M.D.
Joseph P. O'Reilly, C.E.
George F. Fitzgerald, M.A., F.T.C.D.
Alexander Macalister, M.D., F.R.S.
John Casey, LL.D., F.R.S.
Francis A. Tarleton, LL.D., F.T.C.D.
George Sigerson, M.D.
Charles R. C. Tichborne, PH.D.
Sir Robert Kane, LL.D., F.R.S.

Committee of Polite Literature and Antiq

Alexander G. Richey, LL.D., Q.C.
Very Rev. W. Reeves, D.D.
Robert Atkinson, LL.D.
John T. Gilbert, F.S.A.
Rev. Maxwell H. Close, M.A.
John R. Garstin, M.A., F.S.A.
John Kells Ingram, LL.D., F.T.C.D.
William Frazer, F.R.C.S.I.
David R. Pigot, M.A.

In the Department of Polite Literature and Antiquities—

G. I. Ascoli, Milan.
Edward Augustus Bond, LL.D., London.
Heinrich Brugsch, *Pacha*, Göttingen.
Sir Henry James Sumner Maine, LL.D., K.C.S.I., Cambridge.

Sir Robert Kane having left the Chair, it was taken by Sir Samuel Ferguson, the newly elected President.

The Ballot for the Officers of the Academy was then declared open, and Dr. Sigerson and Mr. Archer were nominated Scrutineers.

The Rev. J. H. Jellett, D.D., Provost of Trinity College, proposed, and Dr. Ingram seconded, a vote of thanks to Sir Robert Kane for the dignified and able manner in which he had filled the Presidential Chair during the past quinquennium.

The motion was carried by acclamation, and Sir Robert Kane replied.

The Scrutineers reported the election of the following Officers:—

TREASURER.—Rev. M. H. Close, M.A.
SECRETARY.—Alexander Macalister, M.D.
SECRETARY OF THE COUNCIL.—Robert Atkinson, LL.D.
SECRETARY OF FOREIGN CORRESPONDENCE.—Joseph P. O'Reilly, C.E.
LIBRARIAN.—John T. Gilbert, F.S.A.
CLERK OF THE ACADEMY.—Robert Macalister, LL.B.

The President under his hand and seal nominated the following Vice-Presidents for 1882–83:—

John K. Ingram, LL.D.
Rev. Samuel Haughton, M.D.
John Casey, LL.D.
Very Rev. William Reeves, D.D.

The Academy then adjourned.

LIST

OF THE

COUNCIL AND OFFICERS

AND

MEMBERS

OF THE

OYAL IRISH ACADEMY;

DUBLIN,

25TH OF APRIL, 1882.

DUBLIN:
ACADEMY HOUSE, 19, DAWSON STREET.

1882

THE ROYAL IRISH ACA

A.D. 1882.

Patron:

HER MAJESTY THE QUEE

Visitor:

HIS EXCELLENCY THE LORD LIEUTENA

ROYAL IRISH ACADEMY.

President:

(*First elected*, 16*th of March*, 1882.)
SIR SAMUEL FERGUSON, Q.C., LL.D.

The Council:

(*Elected* 16*th of March*, 1882.)

The Council consists of the Committees of Science and of Polite Literature and Antiquities.

Committee of Science (ELEVEN MEMBERS):

	Elected.	
(1)	Mar., 1876	ROBERT S. BALL, LL.D., F.R.S.
(2)	" 1877	REV. SAMUEL HAUGHTON, M.D., F.R.S., S.F.T.C.D.
(3)	" 1878	EDMUND W. DAVY, M.A., M.D.
(4)	" 1879	JOSEPH P. O'REILLY, C.E.
(5)	" 1879	GEORGE F. FITZGERALD, M.A., F.T.C.D.
(6)	Nov., 1879	ALEXANDER MACALISTER, M.D., F.R.S. (*Sec. of Comm.*)
(7)	Mar., 1880	JOHN CASEY, LL.D., F.R.S.
(8)	" 1881	FRANCIS A. TARLETON, LL.D., F.T.C.D.
(9)	" 1881	GEORGE SIGERSON, M.D.
(10)	Nov., 1881	CHARLES R. C. TICHBORNE, PH.D.
(11)	Mar., 1882	SIR ROBERT KANE, LL.D., F.R.S.

Committee of Polite Literature and Antiquities (TEN MEMBERS):

(12)	Mar., 1869	ALEXANDER GEORGE RICHEY, LL.D., Q.C.
(13)	" 1869	VERY REV. WILLIAM REEVES, D.D.
(14)	" 1870	ROBERT ATKINSON, LL.D. (*Sec. of Comm.*)
(15)	" 1878	*JOHN T. GILBERT, F.S.A.
(16)	Nov., 1878	REV. MAXWELL H. CLOSE, M.A.
(17)	Mar., 1879	JOHN R. GARSTIN, M.A., F.S.A.
(18)	" 1880	JOHN KELLS INGRAM, LL.D., F.T.C.D.
(19)	" 1881	WILLIAM FRAZER, F.R.C.S.I.
(20)	" 1882	DAVID R. PIGOT, M.A.
(21)	April, 1882	THOMAS N. DEANE, R.H.A.

(4) VERY REV. WILLIAM REEVES, D.D., LL.

Officers:

(*Elected annually by the Academy; with date of fi*

TREASURER, ...	REV. MAXW (1878).
SECRETARY, ...	ALEXANDE M.D., (1880).
SECRETARY OF THE COUNCIL, ...	ROBERT ATK
SECRETARY OF FOREIGN CORRESPONDENCE,	JOSEPH P. O'
LIBRARIAN, ...	JOHN T. GI

Clerk of the Academy (elected annually by the Academy)	ROBERT M
Curator, Museum-Clerk, and Housekeeper, .	MAJOR RO
Assistant Accountant, ...	MR. ROBE
Library Clerk, ...	MR. J. J.
Serjeant-at-Mace, ...	MR. J. J.

MEMBERS OF THE ROYAL IRISH ACADEMY.

ORDINARY MEMBERS.

The sign * is prefixed to the names of Life Members.
The sign † indicates the Members who have not yet been formally admitted.
The sign § indicates the Members who have contributed papers to the Transactions of the Academy.
N.B.—The names of *Members whose addresses are not known* to the Secretary of the Academy, are printed in italics. He requests that they may be communicated to him.

Date of Election.	
1866. Jan. 8	Adams, Rev. Benjamin William, D.D. *The Rectory, Santry, Co. Dublin.*
1843. April 10	*§Allman, George James, M.D. (Dub. and Oxon.), LL.D., F.L.S., F.R.C.S.I., F.R.SS., Lond. & Edin., Royal Medalist R.S., 1873. *Ardmore, Parkstone, Dorsetshire; Athenæum Club, London.*
1871. June 12	*†Amherst, William Amhurst Tyssen-, D.L., M.P., F.S.A., M.R.S.L. *Didlington Hall, Brandon, Norfolk.*
1873. Jan. 13	Andrews, Arthur, Esq. *Newtown House, Blackrock, Co. Dublin.*
1839. Jan. 14	*§Andrews, Thomas, M.D., LL.D. (Edin.), F.R.S., Hon. F.R.S.E., F.C.S., Royal Medalist, R.S., 1844. *Fort William Park, Belfast.*
1880. June 28	†Anglin, Arthur H., M.A. *Collegiate House, Broomfield-park, Sheffield.*
1828. April 28	*§Apjohn, James, M.D., F.R.S., F. and Hon. F., K.Q.C.P.I., F.C.S. *South Hill, Blackrock, Co. Dublin.*
1870. Jan. 10	*Archer, William, F.R.S. 57, *Pembroke-road, Dublin.*
1870. April 11	†Ardilaun, Right Hon. Arthur, Baron, M.A., D.L. *Ashford, Cong, Co. Galway; St. Anne's, Clontarf, Co. Dublin.*
1875. Jan. 11	Atkinson, Robert, LL.D., Professor of Sanskrit and Comparative Philology, Univ. Dub., Secretary of Council of the Academy. *Clareville, Upper Rathmines, Co. Dublin.*
1872. April 8	Baily, William Hellier, F.L.S., F.G.S., Geological Survey of Ireland, Demonstrator in Palæontology, R.C.Sc.I. 33, *Moyne-road, Rathmines, Co. Dublin.*
1872. June 24	Baldwin, Thomas, Esq. 67, *Pembroke-road, Dublin.*
1840. April 13	*Ball, John, M.A., F.R.S., F.L.S. 10, *Southwell Gardens, South Kensington, London, S.W.*

Date of Election.	
1870. Jan. 10	§Ball, Robert Stawell, LL.D., F.R.S., F.R Andrews Professor of Astronomy in the U sity of Dublin, and Royal Astronomer of Ir *The Observatory, Dunsink, Co. Dublin.*
1842. Jan. 10	*Banks, John T., M.D., F.K.Q.C.P.I. 45, *Me square, East, Dublin.*
1868. Jan. 13	*Barker, W. Oliver, M.D., M.R.C.S.E. 6, *Gard row, Dublin.*
1874. May 11	Barrett, William F., F.R.S.E., Professor of Ph Royal College of Science. 18, *Belgrave-squar Monkstown, Co. Dublin.*
1866. May 14	Barrington, Sir John, D.L. *Langhton, Kings Co. Dublin.*
1880. Feb. 9	*†Barry, Michael, M.D. 56, *Ventnor-villas, Brig*
1880. Feb. 9	†Barter, Rev. John B. *Rose Hill, Rostellan, M ton, Co. Cork.*
1879. Feb. 10	*Beaney, James G., M.D. *Melbourne, Australi*
1878. June 24	†Beattie, Joseph A., L.R.C.S.I. *Mount Blacq Royal Canal, Dublin.*
1865. Jan. 9	*Beauchamp, Robert Henry, Esq. 25, *Fitzwil square, South, Dublin.*
1863. April 27	*Belmore, Right Hon. Somerset Richard, Ea M.A., D.L., K.C.M.G. *Castle Coole, Ennisk*
1866. June 11	Bennett, Edward Hallaran, M.D., M.Ch., F.R.C F.R.G.S.I., Professor of Surgery in the Un sity of Dublin. 26, *Lower Fitzwilliam-s Dublin.*
1851. June 9	†Beresford, Right Hon. and Most Rev. Marcu D.D., D.C.L., Lord Archbishop of Arm Primate of all Ireland. *The Palace, Armagh*
1876. Jan. 10	*Blake, John A., M.P. 2, *Saville-row, London,*
1879. Jan. 13	Blake, George Dennis, Esq. *St. Columba, B brack, Co. Dublin.*
1871. Jan. 9	Bourke, Very Rev. (Canon) Ulick J. *Kilcol Claremorris.*
1873. April 14	†Boyd, Michael A., F.R.C.S.I., L.K.Q.C.P.I. *Upper George's-street, Kingstown, Co. Dublin.*
1854. April 10	**Brady*, Cheyne, Esq. *(Abroad.)*
1849. April 9	*Brady, Daniel Fredk., F.R.C.S.I., M.R.C.S.E. *La Choza, Rathgar-road, Co. Dublin.*
1858. April 12	†Brooke, Thomas, D.L. *The Castle, Lough Esk Donegal.*
1878. May 13	†Browne, John, Esq. *Drapersfield, Cookstown, Tyrone.*
1851. Jan. 13	*Browne, Robert Clayton, M.A., D.L. *Bro Hill, Carlow.*

Date of Election.	
1874. Feb. 9	†Burden, Henry, M.A., M.D., M.R.C.S.E. 8, *Alfred-street, Belfast.*
1854. April 10	Burke, Sir John Bernard (Ulster), LL.D., C.B. *Tullamaine Villa, Upper Leeson-street, Dublin.*
1855. Jan. 8	*Butcher, Richard G., M.D., F.R.C.S.I., M.R.C.S.E. 19, *Lower Fitzwilliam-street, Dublin.*
1866. April 9	Byrne, John A., B.A., M.B. (Dub.) 21, *Merrion-square, North, Dublin.*
1876. May 8	Byrne, William H., C.E., *Sunbury Gardens, Palmerston-park, Rathmines, Co. Dublin.*
1862. April 14	Campbell, John, M.D., Professor of Chemistry C.U.I. 161, *Rathgar-road, Co. Dublin.*
1873. May 12	†Carlingford, Right Hon. Chichester, Baron, K.P., Lord Lieutenant of Essex. *Red House, Ardee;* 7, *Carlton Gardens, London, S.W.*
1838. Feb. 12	*Carson, Rev. Joseph, D.D., S.F.T.C.D., F.R.G.S.I. 18, *Fitzwilliam-place, Dublin.*
1876. Jan. 10	†Carton, Richard Paul, Q.C. 35, *Rutland-square, West, Dublin.*
1866. May 14	§Casey, John, LL.D., F.R.S., Professor of Higher Mathematics and Mathematical Physics, C.U.I., a Vice-President of the Academy. 86, *South Circular-road, Dublin.*
1873. Jan. 13	†Castletown of Upper Ossory, Right Hon. John Wilson, Baron, Lieutenant of the Queen's County. *Lisduff, Errill, Templemore.*
1878. May 13	*Cathcart, George L., M.A., F.T.C.D. 106, *Lower Baggot-street, Dublin.*
1842. June 13	*Chapman, Sir Benjamin J., Bart., D.L. *Killua Castle, Clonmellon.*
1864. Jan. 11	Charlemont, Right Hon. James Molyneux, Earl of, K.P., Lieutenant of the County Tyrone. *Roxborough Castle, Moy, Co. Armagh.*
1876. April 10	*Clarke, Rev. Francis E., M.A., M.D., L.K.Q.C.P.I., M.R.C.S.E. *Killinagh Rectory, Blacklion, Co. Cavan.*
1841. Jan. 11	*†Clermont, Right Hon. Thomas, Baron, D.L. *Ravensdale Park, Newry.*
1867. May 13	*Close, Rev. Maxwell H., M.A., F.R.G.S.I., F.G.S., Treasurer of the Academy. 40, *Lower Baggot-street, Dublin.*
1835. Nov. 30	**Cole*, Owen Blayney, D.L.
1882. Feb. 13	†Collins, Charles MacCarthy, Esq. *Union Bank of Australia, Melbourne.*
1882. Feb. 13	†Comerford, Rev. Michael, P.P. *Monasterevan, Co. Kildare.*

Date of Election.	
1866. April 9	†Cooper, Lieut. Col. Edward H., Lieutenant of Sligo. Markree Castle, Collooney.
1856. April 14	Copland, Charles, Esq. Royal Bank, Foster-place, D lin; 7, Longford-terrace, Monkstown, Co. Dub
1878. June 24	Corbet, William J., M.P. Springfarm, Delgany.
1880. Dec. 13	†Corry, Thomas Hughes, M.A. Benvue, Wind Park, Belfast.
1864. May 9	†Cotton, Charles Philip, B.A., C.E., F.R.G.S Ryecroft, Bray.
1876. Apr. 10	Cox, Michael Francis, M.A., L.R.C.S.I. 97, Stephen green, South, Dublin.
1882. Feb. 13	*†Cox, William Sidney, C.E. 66, George-str Limerick.
1857. Aug. 24	*§Crofton, Denis, B.A., 8, Mountjoy-square, No Dublin.
1866. June 11	Cruise, Francis R., M.D., F.K.Q.C.P.I., M.R.C.S 93, Merrion-square, West, Dublin.
1870. Apr. 11	Cruise, Richard Joseph, F.R.G.S.I., Geological S vey of Ireland. Castleisland, Co. Kerry; Hume-street, Dublin.
1876. Nov. 13	*†Dalway, Marriott R., D.L. Bella Hill, Carr fergus.
1853. April 11	*Davies, Francis Robert, K.J.J. Hawthorn, Carysf avenue, Blackrock, Co. Dublin.
1855. May 14	*§Davy, Edmund W., M.A., M.D., Prof. of M Jurisprudence, R.C.S.I. 1, Fortfield Terr Templeogue, Co. Dublin.
1846. April 13	*D'Arcy, Matthew P., M.A., D.L. 40, Merrion-squ East, Dublin.
1876. Jan. 10	Day, Robert, Jun., F.S.A. Sidney-place, Cork.
1876. Jan. 10	Deane, Thomas Newenham, R.H.A., F.R.I.A 3, Upper Merrion-street, Dublin.
1846. Jan. 12	*Deasy, Right Hon. Rickard, LL.D., Lord Justice Appeal in Ireland. Carysfort House, Blackr Co. Dublin.
1860. Jan. 9	*Dickson, Rev. Benjamin, D.D., F.T.C.D. 3, Kild place, Dublin.
1876. Feb. 14	Dillon, William, Esq. 2, North Great Geor street, Dublin.
1876. Jan. 10	*§Doberck, William, Ph.D. Observatory, Mark Collooney.
1851. Jan. 13	*Dobbin, Rev. Orlando T., B.D., LL.D. St. Georg terrace, Gravesend, London.
1879. June 9	*Doherty, William J., C.E. Clonturk House, Dru condra, Co. Dublin.

Date of Election.	
1876. June 26	§Draper, Harry N., F.C.S. *Esterel, Temple-road, Upper Rathmines, Co. Dublin.*
1843. Jan. 9	*Drury, William Vallancey, M.D. *Bournemouth.*
1861. Feb. 11	Duncan, James Foulis, M.D., F.K.Q.C.P.I. 8, *Upper Merrion-street, Dublin.*
1867. Feb. 11	Ellis, George, M.B., F.R.C.S.I. 91, *Lower Leeson-street, Dublin.*
1841. April 12	*Emly, Right Hon. William, Baron, Lieutenant of the County Limerick. *Tervoe, Limerick; Athenæum Club, London, S.W.*
1846. Jan. 12	*Enniskillen, Right. Hon. William Willoughby, Earl of, LL.D., D.C.L., D.L., F.R.S., F.R.G.S.I., one of the Trustees of the Hunterian Museum, R.C.S., London. *Florence Court, Co. Fermanagh;* 65, *Eaton-place, London, S.W.*
1867. April 8	*Farrell, Thomas A., M.A. Care of Messrs. Kelly and Co., *Lower Gardiner-street, Dublin.*
1834. Mar. 15	*§Ferguson, Sir Samuel, LL.D., Q.C., President of the Academy. 20, *North Great George's-street, Dublin.*
1842. Jan. 10	*Ferrier, Alexander, Esq. *Knockmaroon Lodge, Chapelizod, Co. Dublin.*
1878. Feb. 11	Fitzgerald, George F., M.A., F.T.C.D. 40, *Trinity College, Dublin.*
1857. Aug. 24	Fitzgerald, Right Rev. William, D.D., Lord Bishop of Killaloe, &c. *Clarisford House, Killaloe.*
1870. May 23	†FitzGibbon, Abraham, M.I.C.E. Lond. *The Rookery, Great Stanmore, Middlesex.*
1841. April 12	*Fitzgibbon, Gerald, M.A., late Master in Chancery. 10, *Merrion-square, North, Dublin.*
1875. Jan. 11	Fitzpatrick, William John, LL.D., J.P. 49, *Fitzwilliam-square, West, Dublin.*
1881. Jan. 10	Fletcher, Joseph, F.C.SS., London and Berlin. *Gilford House, Sandymount, Co. Dublin.*
1860. Jan. 9	Foley, William, M.D., M.R.C.S.E. *Kilrush.*
1874. Feb. 9	†Foster, Rev. Nicholas. *Ballymacelligott Rectory, Tralee.*
1876. Feb. 14	Fottrell, George, Esq. 8, *North Great George's-street, Dublin.*
1838. Nov. 12	**Frazer*, George A., Captain R.N.
1866. May 14	Frazer, William, F.R.C.S.I., F.R.G.S.I. 20, *Harcourt-street, Dublin.*

Date of Election.	
1865. April 10	†Freeland, John, M.D. *Antigua, West Indies.*
1881. June 13	†Freeman, D.J., M.R.I.A.I. 34, *Dawson-street, D*
1847. May 10	*Freke, Henry, M.D. (Dub.), F.K.Q.C.P.I. *Lower Mount-street, Dublin.*
1873. April 14	*†Frost, James, J.P. *Ballymorris, Cratloe, Co. C*
1875. June 14	Furlong, Nicholas, M.D. *Symington, Ennisc*
1859. Jan. 10	Gages, Alphonse, Chev. L.H., F.R.G.S.I. *College of Science,* 51, *Stephen's-green, East, Du*
1845. April 4	*Galbraith, Rev. Joseph Allen, M.A., S.F.T.C F.R.G.S.I. 8, *Trinity College;* 46, *Lansdowne- Dublin.*
1878. May 13	Galloway, Robert, F.C.S. 47, *Leeson-park, D*
1880. June 28	Gannon, John Patrick, Esq. *Laragh, Maynoo*
1864. Jan. 11	*Garnett,* George Charles Lionel, M.A.
1863. Feb. 9	*Garstin, John Ribton, M.A., LL.B., F.S.A., Hist. Soc., Hon. F.R.I.A.I., J.P. *Bragans Castlebellingham, Co. Louth; Green-hill, Kil Co. Dublin.*
1855. April 9	*Gilbert, John Thomas, F.S.A., R.H.A., Libr of the Academy. *Villa Nova, Blackrock, Dublin.*
1876. May 8	Gillespie, William, Esq. *Racefield House, Kings Co. Dublin.*
1875. April 12	*Gore, J. E., C.E., A.I.C.E., F.R.A.S., F.R.G *Beltra, Ballisodare, Co. Sligo.*
1836. May 25	*Gough, Right Hon. George S., Viscount, D.L., F.L.S., F.G.S. *St. Helen's, Booterstown Dublin.*
1848. June 12	*Graham, Andrew, Esq. *Observatory, Cambridge*
1848. April 10	*Graham, Rev. William, D.D. *Bonn.*
1876. April 10	†Grainger, Rev. John (Canon), D.D. *Broughs Co. Antrim.*
1863. April 13	†Granard, Right Hon. George Arthur Hastings, of, K.P. *Castle Forbes, Co. Longford.*
1837. April 24	*§Graves, Right Rev. Charles, D.D., F.R.S., Bishop of Limerick, &c. *The Palace, Henry-st Limerick.*
1874. Feb. 9	Gray, William, Esq. 6, *Mount-Charles, Belfa*
1867. April 8	Green, James S., Q.C. 83, *Lower Leeson-s Dublin.*
1872. April 8	†Greene, John Ball, C.B., C.E., F.R.G.S.I., C missioner of Valuation. 6, *Ely-place, Dublin*
1857. June 8	*Griott, Daniel G., M.A. 9, *Henrietta-street, Du*

Date of Election.	
1873. Dec. 8	*Guinness, Edward Cecil, M.A., D.L. 80, *Stephen's-green, South, Dublin.*
1875. Jan. 11	Hamilton, Edward, M.D., F.R.C.S.I. 120, *Stephen's-green, West, Dublin.*
1879. Dec. 8	Hamilton, Edwin, M.A. 40, *York-street, Dublin.*
1847. Jan. 11	Hancock, William Neilson, Q.C., LL.D. 64B, *Upper Gardiner-street, Dublin.*
1837. Feb. 13	*§Hart, Andrew Searle, LL.D., Vice-Provost of T.C.D. 14, *Lower Pembroke-street; Trinity College, Dublin.*
1861. May 13	Hatchell, John, M.A., J.P. *Forfield House, Terenure, County Dublin.*
1845. Feb. 24	*§Haughton, Rev. Samuel, M.A., M.D., D.C.L. (Oxon.), LL.D. (Cantab.), F.R.S., F.G.S., F.R.G.S.I., F.K.Q.C.P.I., Hon. F.R.C.S.I., S.F.T.C.D., a Vice-President of the Academy. 31, *Upper Baggot-street, Dublin.*
1852. April 12	*Head, Henry H., M.D., F.K.Q.C.P.I., F.R.C.S.I., F.R.G.S.I. 7, *Fitzwilliam-square, East, Dublin.*
1870. April 11	†Heily, John Vickers, M.D. *Lisaduran Cottage, Rushworth, Melbourne, Victoria.*
1840. June 8	*Hemans, George Willoughby, C.E., F.G.S. 1, *Westminster Chambers, Victoria-street, London, S.W.*
1851. Jan. 13	*§Hennessy, Henry, F.R.S., Professor of Applied Mathematics and Mechanics in the Royal College of Science for Ireland, Stephen's-green, Dublin. *Brookvale House, Donnybrook, Co. Dublin.*
1865. Feb. 13	*Hennessy, William Maunsell, Esq. 71, *Pembroke-road, Dublin.*
1873. Jan. 13	Hickie, James Francis, Lieut.-Col. (retired), J.P. *Slevoir, Roscrea, Co. Tipperary.*
1867. Feb. 11	†Hill, John, C.E., F.R.G.S.I. *County Surveyor's Office, Ennis.*
1875. Jan. 11	*Hill, Arthur, B.E., A.R.I.B.A. 22, *George's-street, Cork.*
1881. May 9	†Hillis, John David, M.D., F.R.C.S.I. *Demerara, West Indies.*
1824. Feb. 28	*Hudson, Henry, M.D., F.K.Q.C.P.I. *Glenville, Fermoy.*
1875. June 14	†Hume Rev. Abraham, (Canon), D.C.L., LL.D. (Hon.); F.S.A.; F.R.S.N.A. (Copenhagen); Corr. F.S.A. Scot.; Hon. F.S.A. Newcastle; Member of the Philological and Eng. Dialect Societies; Ex-President Historic Soc. of Lanc. and Cheshire. *All Souls' Vicarage, Liverpool.*

Date of Election.	
1866. June 11	Hutton, Thomas Maxwell, J.P. 118, *Summer* *Dublin.*
1847. Jan. 11	*Ingram, John Kells, LL.D., F.T.C.D., Libra of Trinity College, Dublin, a Vice-Presiden the Academy. 2, *Wellington-road, Dublin.*
1879. April 14	†Ingram, Thomas Dunbar, LL.D. 13, *Wellin road, Dublin.*
1841. April 12	*§Jellett, Rev. John Hewitt, D.D., F.R.G. Provost of Trinity College, Dublin, Royal Meda R.S., 1881. *Provost's House, Trinity Coll Dublin.*
1842. June 13	*Jennings, Francis M., F.G.S., F.R.G.S.I. *Bro street, Cork.*
1867. April 8	Jephson, Robert H., Esq. 30, *Lansdowne-road, Dub*
1881. May 9	Jeremy, Rev. Daniel Davis, M.A. 4, *Appian W Dublin.*
1863. Jan. 12	Joyce, Patrick Weston, LL.D. *Lyre na Gre Leinster-road, Rathmines, Co. Dublin.*
1870. Dec. 12	*†Joyce, Robert D., M.D. 21, *Bowdoin-street, Bos Mass., U.S., America.*
1878. May 13	*Kane, John F., Esq. *Leeson-park House, Dubli*
1831. Nov. 30	*§Kane, Sir Robert, M.D., LL.D., F.K.Q.C.P F.R.S., F.R.G.S.I., F.C.S., Royal Medalist R. 1841. *Fortlands, Killiney, Co. Dublin.*
1873. Dec. 8	*Kane, Robert Romney, M.A. *Dungiven, Ailesbu road, Dublin.*
1865. April 10	Kane, William Francis De Vismes, M.A., J *Sloperton Lodge, Kingstown; Drumreaske Ho Monaghan.*
1870. June 13	*Keane, John P., C.E., Engineer, Public Wo Department, Bengal. *Calcutta.*
1867. Feb. 11	Keane, Marcus, J.P. *Beech Park, Ennis.*
1864. Nov. 14	*Keenan, Sir Patrick J., C.B., K.C.M.G., Resid Commissioner, Board of National Educati Ireland. *Delville, Glasnevin, Co. Dublin.*
1876. May 8	Kelly, James Edward, M.D. 13, *Rutland-squ East, Dublin.*
1870. May 23	*Kelly, John, L.M. (Dub.). *University Col Hospital, Calcutta.*
1846. April 13	*Kennedy, James Birch, J.P. *Cara, by Killarney.*
1874. May 11	†Kidd, Abraham, M.D. *Ballymena.*
1876. Feb. 14	*†Kildare, Most Hon. Gerald, Marquess of. *Car Maynooth.*

Date of Election.	
1875. June 14	†Kilgarriff, Malachy J., F.R.C.S.I. 30, *Harcourt-street, Dublin.*
1866. April 9	*Kinahan, Edward Hudson, J.P. 11, *Merrion-square, North, Dublin.*
1868. Jan. 13	Kinahan, George Henry, F.R.G.S.I., Geological Survey of Ireland. *Ovoca, Co. Wicklow*; 14, *Hume-street, Dublin.*
1863. April 13	Kinahan, Thomas W., M.A. 24, *Waterloo-road, Dublin.*
1845. June 8	*King, Charles Croker, M.D., F.R.C.S.I., Medical Commissioner, Local Government Board. 34, *Upper Fitzwilliam-street, Dublin.*
1837. Feb. 13	*§*Knox*, George J., Esq.
1864. April 11	*Lalor, John J., F.R.G.S.I. *City Hall, Cork-hill, Dublin.*
1875. May 10	†Lane, Alexander, M.D. *Ballymoney.*
1864. Jan. 11	LaTouche, J. J. Digges, M.A. 1, *Ely-place, Upper, Dublin.*
1836. Jan. 25	*LaTouche, William Digges, M.A., D.L. 34, *Stephen's-green, North, Dublin.*
1857. May 11	*Lawson, Right Hon. James A., LL.D., Justice of the Court of Common Pleas. 27, *Upper Fitzwilliam-street, Dublin.*
1857. April 13	*Leach, Lieut.-Colonel George A., R.E. 3, *St. James's-square, London, S.W.*
1845. Feb. 10	*LeFanu, William R., C.E. *Summerhill, Enniskerry, Co. Wicklow.*
1846. May 11	**Lefroy*, George, Esq. (*Abroad.*)
1844. April 8	*†Leinster, His Grace Charles William, Duke of, President of the Royal Dublin Society. *Carton, Maynooth.*
1869. April 12	*Lenihan, Maurice, J.P. *Limerick.*
1853. April 11	Lentaigne, Sir John, C.B., M.B., J.P., F.R.G.S.I. 1, *Great Denmark-street, Dublin.*
1870. June 13	Leonard, Hugh, F.G.S., F.R.G.S.I., Geological Survey of Ireland. *St. David's, Malahide-road, Dublin.*
1868. April 27	*Little, James, M.D., L.R.C.S.I., F.K.Q.C.P.I. 14, *Stephen's-green, North, Dublin.*
1876. Jan. 10	Lloyd, Joseph Henry, M.A., LL.D., PH. D., F.R.S.L., F.S.A., M. Phil. Soc. 7, *Lower Gardiner-street, Dublin.*
1846. Jan. 12	**Lloyd*, William T., M.D.
1875. April 12	Lombard, James F., J.P. *South-hill, Rathmines, Co. Dublin.*

Date of Election.	
1838. Feb. 12	*Longfield, Right Hon. Mountifort, LL.D. (late Ju in the Landed Estates' Court). 47, *Fitzwilli square, West, Dublin.*
1878. Feb. 11	*†Lowry, Robert William, B.A. (Oxon.) D.L., J. *Pomeroy House, Dungannon, Co. Tyrone.*
1868. Jan. 13	Lyne, Robert Edwin, Esq. 2, *Hargrave-terr Terenure-road, Rathgar, Co. Dublin.*
1851. May 12	*Lyons, Robert D., M.B., F.K.Q.C.P.I., M. Prof. of Medicine, C.U.I. 88, *Merrion-squa West, Dublin.*
1873. April 14	§Macalister, Alexander, M.D., F.R.S., L.R.C.S. L.K.Q.C.P.I., F.R.G.S.I., Professor of Anato and Comparative Anatomy in the University Dublin, Secretary of the Academy. 11, *Up Fitzwilliam-street, Dublin.*
1871. Feb. 13	*Macartney, J. W. Ellison, M.P., J.P. *The Pala Clogher.*
1875. Jan. 11	†MacCarthy, John G., Esq. *River View, Montenotte, Co*
1881. June 27	†McClintock, Rev. Francis Le Poer, M.A. (Cantal *Spencer Hill, Castlebellingham, Co. Louth.*
1874. Feb. 9	McClure, Rev. Edmund, M.A. *Society for P moting Christian Knowledge, Northumberlan avenue, Charing Cross, London, S.W.*
1873. Jan. 13	*McCready, Rev. Christopher, M.A. 56, *High-stre Dublin.*
1864. April 11	*McDonnell, Alexander, M.A., C.E., F.R.G.S.I. *John's, Island-bridge, Co. Dublin.*
1845. Feb. 24	**Macdonnell*, James S., C.E.
1827. Mar. 16	*MacDonnell, John, M.D., F.R.C.S.I., F.R.G.S 32, *Upper Fitzwilliam-street, Dublin.*
1857. Feb. 9	*§McDonnell, Robert, M.D., F.R.C.S.I., F.R.S. *Merrion-square, West, Dublin.*
1865. April 10	†Mac Donnell, Lieut.-Col. William Edward Ar strong, Vice-Lieutenant of the County Clare. *Hall, near Ennis.*
1882. Feb. 13	McHenry, Alexander, Esq., Geological Survey Ireland. 6, *Ashford-terrace, Ball's Bridge, Dubl*
1856. June 9	*†Mac Ivor, Rev. James, D.D., F.R.G.S.I. *Moy Newtownstewart.*
1876. April 10	MacIlwaine, Rev. William (Canon), D.D. *Ulsterv Belfast.*
1881. Feb. 14	§Mackintosh, Henry William, M.A., Professor Zoology in the University of Dublin. *Trin College, Dublin.*
1871. April 10	Macnaghten, Colonel Sir Francis Edmund, Ba (Late 8th Hussars), Vice-Lieutenant of the C Antrim. *Dundarave, Bushmills, Co. Antrim.*

Date of Election.	
1874. April 13	MacSwiney, Stephen Myles, M.D. 38, *York-street, Dublin.*
1846. Feb. 23	*Madden, Richard R., F.R.C.S. Eng. 1, *Vernon-terrace, Booterstown-avenue, Booterstown, Co. Dublin.*
1864. June 13	Madden, Thomas More, M.D., L.K.Q.C.P.I., M.R.C.S.E. 55, *Merrion-square, South, Dublin.*
1882. April 10	†Mahony, Richard John, B.A. (Oxon.) D.L. *Dromore Castle, Kenmare, Co. Kerry.*
1880. May 10	†Mahony, William Aloysius, L.K.Q.C.P.I., L.R.C.S. Edin. *Mitchelstown, Co. Cork.*
1874. Feb. 9	§Malet, John Christian, M.A., Professor of Mathematics. *Queen's College, Cork.*
1865. April 10	*Malone, Rev. Silvester, P.P., F.R.H.A.A.I. *Sixmilebridge, Co. Clare.*
1859. Jan. 10	*†Manchester, His Grace William Drogo, Duke of. 1, *Great Stanhope-street, London; Kimbolton Castle, St. Neot's, Hunts; The Castle, Tanderagee.*
1871. Jan. 9	Maunsell, George Woods, M.A., D.L., Vice-President, Royal Dublin Society. 78, *Merrion-square, South, Dublin.*
1879. Feb. 10	Meldon, Austin, M.D. 15, *Merrion-square, North, Dublin.*
1861. Jan. 14	†Monck, Right Hon. Charles Stanley, Viscount, G.C.M.G., Lieutenant of Dublin City and County. *Charleville, Bray, Co. Wicklow.*
1858. Jan. 11	**Montgomery*, Howard B., M.D.
1860. Jan. 9	Moore, Alexander G. Montgomery, Colonel, Assistant Adjutant-General. *Royal Hospital, Kilmainham.*
1861. Jan. 14	Moore, James, M.D., M.R.C.S.E. 7, *Chichester-street, Belfast.*
1869. Feb. 8	*Moran, Most Rev. Patrick F., D.D., Bishop of Ossory. *St. Kyran's College, Kilkenny.*
1866. April 9	More, Alexander Goodman, F.L.S., Soc. Zoo. Bot. Vindob. Socius, Director of the Natural History Museum, Science and Art Department, Leinster House. 92, *Leinster-road, Rathmines, Co. Dublin.*
1874. Feb. 9	§Moss, Richard J., F.C.S., Keeper of the Minerals, Museum of Science and Art. 66, *Kenilworth-square, Rathgar.*
1876. April 10	†Myers, Walter, Esq. 2, *Richard-street, Spencer-street, Birmingham.*
1840 Feb. 10	*Napier, Right Hon. Sir Joseph, Bart., D.C.L., LL.D., *University Club, Dublin.*
1844. June 8	*Neville, John, C.E., F.R.G.S.I. *Roden-place, Dundalk.*

Date of Election.	
1854. May 8	Neville, Parke, C.E. 58, *Pembroke-road, Dublin*
1873. Jan. 13	Nolan, Joseph, F.R.G.S.I., Geological Survey Ireland. 47, *Great James's-street, Derry;* *Hume-street, Dublin.*
1846. Jan. 12	*†Nugent, Arthur R., Esq. *(Portaferry, Co. Dow*
1869. June 14	*O'Brien, James H., Esq. *St. Lorcan's, Howth,* *Dublin.*
1875. Jan. 11	O'Callaghan, J. J., F.R.I.A.I. 31, *Harcourt-str* *Dublin.*
1867. June 10	O'Conor Don, The, D.L. *Clonalis, Castlerea,* *Roscommon.*
1867. Jan. 14	O'Donel, Charles J., J.P. 47, *Lower Leeson-str* *Dublin.*
1865. Apr. 10	O'Donnavan, William J., LL.D. *University Cl* 17, *Stephen's-green, North, Dublin;* 79, *Kenilwor* *square, Rathgar, Co. Dublin.*
1869. Apr. 12	†O'Ferrall, Ambrose More, J.P. *Balyna Ho* *Enfield, Co. Kildare.*
1882. Apr. 10	†O'Farrell, Francis J., F.C.S. *The Manor Hou* *Dundrum.*
1866. Jan. 8	*O'Grady, Edward S., B.A., M.B., M. Ch., F.R.C.S 105, *Stephen's-green, South, Dublin.*
1867. May 13	†O'Grady, Standish H., Esq. *Erinagh House, Cast* *connell;* 2, *Southampton-st., Strand, London, W.*
1866. June 25	O'Hagan, Hon. John, M.A., Judge of the Supre Court of Judicature in Ireland, and Judicial Co missioner Irish Land Commission. 22, *Up* *Fitzwilliam-street, Dublin.*
1857. June 8	O'Hagan, Right Hon. Thomas, Baron, K.P. *Wo* *lands, Clonsilla, Co. Dublin.*
1869. Apr. 12	O'Hanlon, Very Rev. John, P.P. *Sandymount,* *Dublin.*
1878. Feb. 11	O'Hanlon, Michael, L.K.Q.C.P.I. *Castlecom* *Co. Kilkenny.*
1866. Jan. 8	O'Kelly, Joseph, M.A., F.R.G.S.I., Geological Surv of Ireland. 72, *Eccles-street, Dublin;* 14, *Hu* *street, Dublin.*
1869. Apr. 12	O'Laverty, Rev. James, P.P. *Holywood, near Belfa*
1876. Feb. 14	Olden, Rev. Thomas, B.A. *Ballyclough, Mallo* *Co. Cork.*
1871. Apr. 10	O'Looney, Brian, F.R.H.S., Professor of Irish La guage, Literature, and Archæology to the Catho University of Ireland, *Grove-villa House, Cruml* *Co. Dublin.*
1861. June 10	*O'Mahony, Rev. Thaddeus, D.D. *Trinity Colle* *Dublin.*

Date of Election.	
1870. Jan. 10	§O'Reilly, Joseph P., C.E., Prof. of Mining and Mineralogy, Royal College of Science, Dublin, Secretary of Foreign Correspondence of the Academy. 58, *Park-avenue, Sandymount, Co. Dublin.*
1878. May 13	O'Reilly, Rev. John, C.C. 13, *North Richmond-street, Dublin.*
1879. May 12	†O'Rorke, Very Rev. Terence, D.D., P.P. *Collooney, Sligo.*
1866. June 11	O'Rourke, Very Rev. (Canon) John, P.P. *St. Mary's, Maynooth.*
1838. Dec. 10	*Orpen, John Herbert, LL.D. 58, *Stephen's-green, East, Dublin.*
1870. Feb. 14	O'Shaughnessy, Mark S., LL.D., F.R.S.L., Regius Prof. of English Law, Queen's College, Cork. 27, *St. Patrick's-hill, Cork.*
1866. Jan. 8	O'Sullivan, Daniel, Ph. D. *Rosemount, North Circular-road, Dublin.*
1839. June 10	*Parker, Alexander, J.P. 46, *Upper Rathmines, Co. Dublin.*
1873. Feb. 10.	Patterson, William Hugh, Esq., *Garranard, Strandtown, Belfast.*
1847. Feb. 8	*†Pereira [elected as Tibbs], Rev. Henry Wall, M.A., F.S.A. Scot.,&c. *Sutton Wick, Abingdon.*
1872. Apr. 8	Phayre, Major-General Sir Arthur Purves, K.C.S.I., G.C.M.G., C.B. *Bray, Co. Wicklow.*
1863. Apr. 13	Pigot, David R., M.A., Master, Court of Exchequer. 12, *Leeson-park, Dublin.*
1870. Apr. 11	Pigot, Thomas F., C.E., Prof. of Descriptive Geometry, etc., Royal College of Science, Dublin. 4, *Wellington-road, Dublin.*
1838. Feb. 12	*Pim, George, J.P. *Brennanstown, Cabinteely, Co. Dublin.*
1849. Jan. 8	*Pim, Jonathan, Esq. *Greenbank, Monkstown, Co. Dublin.*
1880. Feb. 9	Plunkett, Thomas, F.R.G.S.I. *Enniskillen.*
1864. Jan. 11	*†*Poore*, Major Robert, (Late 8th Hussars). *(Abroad.)*
1862. Apr. 14	*Porte, George, Esq. 43, *Great Brunswick-st., Dublin.*
1873. Jan. 13	*Porter, Alexander, M.D., F.R.C.S., Assist.-Surgeon, Indian Army. *Madras.*
1875. Jan. 11	†Porter, George Hornidge, M.D., Surgeon in Ordinary to the Queen in Ireland, M. Ch. 3, *Merrion-square, North, Dublin.*
1852. Apr. 12	**Porter*, Henry J. Ker, Esq.
1873. Jan. 13	Powell, George Denniston, M.D., L.R.C.S.I. 76, *Upper Leeson-street, Dublin.*
1864. June 13	†Power, Sir Alfred, K.C.B., M.A. 35, *Raglan-road, Dublin.*

Date of Election.	
1875. April 12	*†Powerscourt, Right Hon. Mervyn Wingfield Viscount. *Powerscourt, Enniskerry, Bray.*
1854. Jan. 9	Pratt, James Butler, C.E. *Drumsna, Co. Leitrim.*
1874. Dec. 14	*†Purcell, Mathew John, Esq. *Burton Park, Church town, Co. Cork; Stephen's-green Club, Dublin.*
1858. Jan. 11	Purser, John, M.A., D.Sc., Professor of Mathe matics. *Queen's College, Belfast.*
1881. Apr. 11	*Quinlan, Francis John Boxwell, B.A., M.D F.K.Q.C.P.I. 29, *Lower Fitzwilliam-street, Dubli*
1867. Jan. 14	*†Read, John M., General, U.S.; Consul-General the U.S.A. for France and Algeria, Member American Philos. Soc., Fellow of the Royal So of Northern Antiquaries, &c. *Athens.*
1846. Dec. 14	*§Reeves, Very Rev. William, D.D., M.B., LL.D Dean of Armagh, a Vice-President of Academ *The Public Library, Armagh; Rectory, Tynan.*
1843. Feb. 13	*§*Renny*, Henry L., F.R.G.S.I., Lieut. R.E., (Retire List). [*Quebec* ?]
1878. June 24	*Reynell, Rev. William A., B.D. 8, *Henrietta-stre Dublin.*
1875. Jan. 11	Reynolds, James Emerson, M.D., F.R.S., Pr fessor of Chemistry in the University of Dubli 62, *Morehampton-road, Donnybrook, Co. Dubli*
1867. Apr. 8	Richey, Alexander George, LL.D., Q.C. 27, *Upp Pembroke-street, Dublin.*
1875. June 14	Robertson, John C., L.K.Q.C.P.I., M.R.C.S.I F.R.A.S. *The Asylum, Monaghan.*
1881. Jan. 10	Robinson, John L., C.E., M.R.I.A.I. 48, *Clarinda park, East, Kingstown, Co. Dublin.*
1844. June 10	*Roe, Henry, M.A. *(Isle of Man.)*
1876. Jan. 10	*†Ross, Rev. William. *Chapel Hill House, Rothesa*
1870. Nov. 30	Rosse, Rt. Hon. Lawrence, Earl of, D.C.L., D.I F.R.S., F.R.A.S. *Birr Castle, Parsonstown.*
1872. Apr. 8	Rowley, Standish G., LL.D., J.P., M.R.S.L. *Sylva park, Kells, Co. Meath.*
1843. Jan. 9	*§Salmon, Rev. George, D.D., D.C.L. (Oxon.), LL.I (Cantab.), F.R.S., and Royal Medalist, 186 Regius Professor of Divinity in the University Dublin. 81, *Wellington-road, Dublin.*
1853. Jan. 10	*Sanders, Gilbert, Esq. *Albany Grove, Monkstown County Dublin.*
1851. May 12	*Sayers, Rev. Johnston Bridges, LL.D. *Velore, Madra*
1846. Feb. 9	*†Sherrard, James Corry, Esq. 7, *Oxford-squar Hyde-park, London.*

Date of Election.	
1873. Jan. 13	*†Shirley, Evelyn Philip, M.A., D.L., F.S.A. *Lough Fea, Carrickmacross; Ettington Park, Stratford-on-Avon.*
1869. Apr. 12	Sigerson, George, M.D., M.Ch., F.L.S., Prof. of Botany, C.U.I. 3, *Clare-street, Dublin.*
1835. Feb. 23	*§Smith, Aquilla, M.D., F.K.Q.C.P.I. 121, *Lower Baggot-street, Dublin.*
1877. Dec. 10	*†Smith, Charles, Esq. *Barrow-in-Furness.*
1868. Jan. 13	†Smith, John Chaloner, C.E. *Engineer's Office, Dublin, Wicklow and Wexford Railway, Bray.*
1833. Apr. 22	*Smith, Joseph Huband, M.A.
1876. June 26	Smith, Rev. Richard Travers, (Canon) B.D. *The Vicarage, Clyde-road, Dublin.*
1873. Jan. 13	Smyth, Patrick James, M.P., Chev. L. H. 15, *Belgrave-square, East, Rathmines, Co. Dublin.*
1867. Jan. 14	Smythe, William Barlow, M.A., D.L. *Barbavilla House, Collinstown, Killucan.*
1873. April 14	*Smythe, William James, Lieutenant-General, R.A., F.R.S. *Coole Glebe, Carnmoney, Belfast.*
1874. Dec. 14	Stewart, James, M.A. (Cantab.), Professor of Greek and Latin, C.U.I. 21, *Gardiner's-place, Dublin.*
1871. June 12	§Stokes, Hon. Whitley, LL.D., C.S.I., Member of the Supreme Council of India. *Legislative Council House, Calcutta.*
1874. June 22	Stokes, William, M.D., M. Ch. 5, *Merrion-square, North, Dublin.*
1857. June 8	*§Stoney, Bindon B., M.A., C.E., F.R.S., F.R.G.S.I. 14, *Elgin-road, Dublin.*
1856. Apr. 14	§Stoney, George Johnstone, M.A., D.Sc., F.R.S., 3, *Palmerston-park, Upper Rathmines.*
1857. Aug. 24	*Sullivan, William Kirby, Ph.D., President of Queen's College, Cork. *Queen's College, Cork.*
1874 Apr. 13	†Sweetman, H. S., Esq. 38, *Alexandra-road, St. John's Wood, London, N.W.*
1845. Feb. 24	*Sweetman, Walter, J.P. 4, *Mountjoy-square, North, Dublin.*
1871. Jan. 9	†Symons, John, Esq. 72, *Queen-street, Hull.*
1845 June 23	*Talbot de Malahide, Right Hon. James, Baron, D.C.L., D.L., F.R.S., F.S.A., F.G.S., F.R.G.S.I., F.R. Hist. Soc., Pres. Archæol. Inst. *The Castle, Malahide, Co. Dublin.*
1877. April 9	§Tarleton, Francis Alexander, LL.D., F.T.C.D. 24, *Upper Leeson-street, Dublin.*
1869. Apr. 12	§Tichborne, Charles Roger C., Ph.D., F.C.S. 15, *North Great George's-street, Dublin; Apothecaries' Hall, 40, Mary-street, Dublin.*

Date of Election.	
1864. Mar. 16	Trench, Right Hon. and Most Rev. Richard Cher vix, D.D., Lord Archbishop of Dublin, Prim of Ireland. *The Palace, Stephen's-green, Nor Dublin.*
1879. June 9	*†Tucker, Stephen Isaacson, Esq., Somerset Heral *Heralds' College, London, E.C.*
1846. Feb. 9	*Tuffnell, Thomas Joliffe, F.R.C.S.I., M.R.C.S. 58, *Lower Mount-street, Dublin.*
1871. June 12	†Tyrrell, Colonel Frederick, J.P. *Gold Coast Colo Accra, care of Forbes & Co., 25, Cockspur-stre London, S.W.*
1876. April 10	*†Tyrrell, George Gerald, Esq., Clerk of the Crow Co. Armagh. 30, *Upper Pembroke-street, Dubli Banbridge, Co. Down.*
1870. Nov. 30	†Ventry, Right Hon. Dayrolles Blakeney, Baro D.L. *Burnham-house, Dingle, Co. Kerry.*
1880. Feb. 9	†Vesey, Agmondisham B., L.K.Q.C.P.I. *Beller Magherafelt.*
1881. Feb. 14	*Ward, Francis Davis, J.P., *Clonaver, Strandtow Belfast.*
1864. Feb. 8	*†Warren, James W., M.A. 39, *Rutland-square, We Dublin.*
1881. Jan. 10	*†Watts, Robert George, M.D., F.R.S.L., 5, *Bulstrod street, Cavendish-square, London, W.*
1866. Apr. 9	Westropp, W. H. Stacpoole, L.R.C.S.I., F.R.G.S.I &c. *Lisdoonvarna, Co. Clare.*
1876. Nov. 13	†White, Rev. Hill Wilson, LL.D., *Wilson's Hospita Multifarnham, Co. Westmeath.*
1880. Feb. 9	*†White, John Newsom, Esq. *Rocklands, Waterfor*
1857. June 8	*†Whitehead, James, M.D., F.R.C.S.E., M.R.C. Phy Lon. 87, *Mosley-street, Manchester.*
1851. Jan. 13	*†Whittle, Ewing, M.D., M.R.C.S.E. 1, *Parliamen terrace, Liverpool.*
1874. June 8	Wigham, John R., Esq. 35, *Capel-street, Dublin.*
1873. April 14	Wilkinson, Thomas, Esq. *Enniscorthy, Co. Wexfor*
1839. Jan. 14	*Williams, Richard Palmer, F.R.G.S.I. 38, *Dam street., Dublin.*
1837. Jan. 9	*Williams, Thomas, Esq. 38, *Dame-street, Dubli*
1877. April 9	Williamson, Benjamin, M.A., F.R.S., F.T.C.I 1B, *Dartmouth-road, Dublin.*
1857. Aug. 24	*§Wright, Edward Perceval, M.A., M.D., F.L.S F.R.C.S.I., J.P., Professor of Botany and Keep of the Herbarium, Dublin University. 5, *Trini College, Dublin.*

HONORARY MEMBERS.

Date of Election.	
1863. June 22	HIS ROYAL HIGHNESS ALBERT EDWARD, PRINCE OF WALES.

"*The* PRESIDENT OF THE ROYAL SOCIETY, AND EX-PRESIDENTS *of the same, are always considered Honorary Members of the Academy.*"—By-Laws, ii., 14.

1869. Mar. 16 (Elected Hon. Mem. in Sec. of Science originally.)	Hooker, Sir Joseph Dalton, M.D., K.C.B., F.R.S., D.C.L., LL.D., V-P.L.S., F.G.S., Director of the Royal Gardens, Kew, EX-PRESIDENT OF THE ROYAL SOCIETY. *Kew, London, W.*
1863. Mar. 16	Sabine, General Sir Edward, R.A., K.C.B., D.C.L., LL.D., V.P. and EX-PRESIDENT OF THE ROYAL SOCIETY, Hon. F.R.S., Edin., F.R.A.S., F.L.S., &c. 13, *Ashley-place, Westminster, London, S.W.*
1832. Nov. 30 (Elected Hon. Mem. in Sec. of Science originally.)	Airy, Sir George Biddell, K.C B., D.C.L., LL.D., EX-PRESIDENT OF THE ROYAL SOCIETY (1871), V-P. R.A.S., &c. *Playford, near Ipswich.*
1880. Mar. 16	Spottiswoode, William, M.A., D.C.L., LL.D., PRESIDENT OF THE ROYAL SOCIETY. 41, *Grosvenor-place, London, S.W.*

SECTION OF SCIENCE.

[Limited to 30 Members, of whom one-half at least must be foreigners.]

1873. Mar. 15	Adams, John Couch, LL.D. (Dub.), F.R.S. and Copley Medalist, V-P.R.A.S., F.C.P.S., etc., Director of the Observatory and Lowndesean Professor of Astronomy and Geometry in the University of Cambridge. *Observatory, Cambridge.*
1874. Mar. 16	Berthelot, Professor Marcelin Pierre Eugène. *Boulevard Saint-Michel,* 57, *Paris.*
1875. Mar. 16	Bertrand, Professor Joseph Louis François. *Paris.*
1869. Mar. 16	Brown-Séquard, Charles Edouard, M.D., F.R.C.P., F.R.S. *Collège de France, Rue Gay Lussac, Paris.*
1869. Mar. 16	Bunsen, Professor Robert Wilhelm Eberard. *Heidelberg.*
1869. Mar. 16	Carus, J. Victor, Professor of Comparative Anatomy. *Leipzig.*
1873. Mar. 15	Cayley, Arthur, LL.D. (Dub.), F.R.S., V-P. R.A.S., &c., Sadlerian Professor of Mathematics in the University of Cambridge. *Cambridge.*

HONORARY MEMBERS—*Continued.*

SECTION OF SCIENCE—Continued.

Date of Election.	
1866. Mar. 16	Clausius, Prof. Rudolf Julius Emmanuel. *Zürich.*
1873. Mar. 15	Dana, James Dwight, LL.D., &c., Professor of Geology and Mineralogy. *Yale College, New Hav Conn., U. S. America.*
1869. Mar. 16	Daubrée, Prof. Gabriel Auguste. *Ecole des Min Paris.*
1876. Mar. 16	Decandolle, Alphonse, Professor of Botany. *Genev*
1841. Mar. 16	Dumas, Professor Jean Baptiste, G.C.L.H. *Rue S Dominique, 69, Paris.*
1875. Mar. 16	Gray, Asa, Professor of Botany, Harvard Universit *Cambridge, Massachusetts, U. S. America.*
1876. Mar. 16	Haeckel, Ernst, Professor of Zoology. *Jena.*
1880. Mar. 16	Heer, Oswald, Prof. of Botany in Univ. *Zürich.*
1864. Mar. 16	Helmholtz, Professor Hermann Ludwig Ferdinan *Berlin.*
1873. Mar. 15	Hofmann, August Wilhelm, F.R.S., Professor of Chemistry in the University. *Berlin.*
1879. Mar. 16	Huggins, William, D.C.L., LL.D., F.R.S. *Uppe Tulse-hill, London, S.W.*
1874. Mar. 16	§Huxley, Professor Thomas Henry, LL.D., F.R.S *London.*
1864. Mar. 16	Hyrtl, Professor Karl Joseph. *Vienna.*
1880. Mar. 16	Loomis, Professor Elias. *Yale College, U.S. Ameri*
1880. Mar. 16	Marsh, Prof. O. C. *Yale College, Conn., U.S. America*
1882. Mar. 16	Newcomb, Simon. *United States Naval Observator Washington.*
1878. Mar. 16	Pasteur, Louis. *Paris.*
1882. Mar. 16	Smith, Henry John Stephen, F.R.S., Savilian Pr fessor of Geometry, Oxford. *Oxford.*
1873. Mar. 15	Stokes, George Gabriel, D.C.L., LL.D. (Dub.), Fe low and Secretary of the Royal Society, F.C.P.S F.R.S. Ed., &c., Lucasian Professor of Mathematic in the University of Cambridge. *Lensfield Cottag Cambridge.*
1878. Mar. 16	Thomson, Professor Sir William, LL.D., D.C.L F.R.S. *Glasgow.*
1882. Mar. 16	Virchow, Rudolph. *Berlin.*
1867. Mar. 16	Würtz, Professor Adolf Karl. *Rue St. Guillaum 27, Paris.*

(*One vacancy.*)

SECTION OF POLITE LITERATURE & ANTIQUITIES.

[Limited to 30 Members, of whom one-half at least must be foreigners.]

Elected in the Department of Polite Literature.

Date of Election.	
1869. Mar. 16	Gayangos y Arce, Don Pascual de. *London.*
1869. Mar. 16	Lassen, Professor Christian. *Bonn.*
1849. Nov. 30	Lepsius, Professor Karl Richard. *Berlin.*
1869. Mar. 16	Mommsen, Professor Theodor. *Berlin.*
1863. Mar. 16	Müller, Professor Max. *Oxford.*

Elected in the Department of Antiquities.

1869. Mar. 16	Benavides, Don Antonio. *Madrid.*
1848. Nov. 30	Botta, Paul Emile. *Paris.*
1867. Mar. 16	De Rossi, Commendatore Giovanni Battista. *Rome.*
1841. Mar. 16	Halliwell-Phillipps, James Orchard, F.R.S., F.SS.A. Lond. and Scotland., &c. *Hollingbury Copse, Brighton.*
1854. Mar. 16	Maury, Professor Louis Ferdinand Alfred. *Paris.*
1866. Mar. 16	Nilsson, Professor Sven. *Lund.*
1867. Mar. 16	Visconti, Barone Commendatore P. E. *Rome.*
1867. Mar. 16	Worsaae, Prof. Hans Jakob Asmussen. *Copenhagen.*

Elected since the union of the two classes of Honorary Members in this Section.

1882. Mar. 16	Ascoli, Professor G. I. *Milan.*
1878. Mar. 16	Bradshaw, Henry, M.A., University Librarian, *Cambridge.*
1882. Mar. 16	Bond, Edward Augustus, LL.D., Principal Librarian of the British Museum. *London.*
1882. Mar. 16	Brugsch-Pascha, Heinrich. *Berlin.*
1878. Mar. 16	Curtius, Professor Georg. *Leipzig.*
1875. Mar. 16	Franks, Augustus Wollaston, M.A., F.R.S., F.S.A. 103, *Victoria-street, London, S. W.*
1880. Mar. 16	Fick, Professor F. C. August. *Göttingen.*
1878. Mar. 16	Kern, Professor H. *Leyden.*
1882. Mar. 16	Maine, Sir Henry James Sumner, LL.D., K.C.S.I., Master of Trinity Hall, Cambridge. *Cambridge.*
1878. Mar. 16	Newton, Charles, C.B., D.C.L., F.S.A. *British Museum, London.*
1873. Mar. 15	Nigra, His Excellency Cavaliere Constantino, Italian Minister to Russia. *St. Petersburg.*
1876. Mar. 16	Stokes, Margaret. *Carrig-Breac, Howth, Co. Dublin.*

Date of Election.	
1876. Mar. 16	Stubbs, Rev. William, D.D., Canon of St. Pa London, Professor of Modern History, Oxf *Oxford.*
1873. Mar. 15	Westwood, John Obadiah, Esq., F.S.A., H Professor of Zoology, Oxford. *Oxford.*
1875. Mar. 16	Whitney, Prof. William Dwight. *Yale Coll Connecticut, U.S., America.*
1876. Mar. 16	Windisch, Professor Ernst. *Leipzig.*

(*One vacancy.*)

SUMMARY.

Life Members	...	...	...	152
Annual Members	...	...	...	178
				330
Honorary Members (58 + 5) ...			...	63
		Total,	...	393

Should any errors or omissions be found in this Lis
1st April, 1882, it is requested that notice thereo
Secretary of the Academy. He should also be infor
Member.

As this list will be kept standing in type, it can be rea
to time.

MONDAY EVENING, DECEMBER, 11, 1882.

SIR SAMUEL FERGUSON, Q.C., LL.D., President, in the Chair.

Mr. Frederick H. Houston and Mr. John Fraser O'Reardon, having signed the Roll, were admitted Members of the Academy.

Mr. Thomas Greer, M.P., was elected a Member of the Academy.

Dr. Frazer read a Paper "On the Medals and Medallic History of Ireland." Nos. 1 and 2, W. S. Mossop, Senr., and W. S. Mossop, Junr.

Dr. Macalister read a Paper "On Additional Evidence as to the existence of a Family of Horned Men in West Africa.

Dr. Macalister read also a Paper "On a Cranium from Lord Howe's Island."

Dr. Macalister exhibited for Miss Lily Ashley, now residing at Aleik, Lebanon, Sketches of Ancient Monumental Stones from Lebanon, with Inscriptions, believed to be funereal.

Rev. J. B. Berkeley Barter presented to the Academy an ancient Harp, which some generations back was the instrument used by an old Irish Harper, by whom it was bequeathed to the Rev. Mr. Best, a Sligo clergyman, with the history that it had been an heirloom in his family. From Mr. Best it passed to a descendant, Mrs. Bestic, from whom it was obtained by Mr. Barter on the occasion of the Moore Centenary. It is 46 inches high, with a trunk and sounding-board of red sally, with 35 bronze pegs, and a kind of handle wherewith the minstrel could carry it.

The Academy accorded to the Rev. Mr. Barter a special vote of thanks for his donation.

The Secretary read the list of Donations, and the thanks of the Academy were accorded to the respective Donors.

The following Scientific Grants, recommended by the Council, were confirmed :—

£20 to Messrs. F. P. Balkwill and Joseph Wright in aid of further Researches in the Foramenifera of Dublin Bay.

£25 to Dr. Macalister to purchase Skulls of the Peninsular and Insular Races of Western Europe, for comparison with Irish Crania.

MONDAY EVENING, JANUARY 22, 1883.

SIR SAMUEL FERGUSON, Q.C., LL.D., President, in the Chair.

Professor Valentine Ball, F.R.S., read a Paper "On Indian Br Castings."

Dr. Macalister read "A Description of a Series of Egypti Scarabæi," which he exhibited.

Dr. Macalister read a Paper "On the Crania of Natives of t Solomon Islands," which was illustrated by the exhibition of t Crania.

The Secretary read for Mr. H. C. Hart "A Report on the Bota of the Mayo and Galway Mountains."

The Secretary read, on behalf of Captain Dunne, an account a Canoe from Castlebar, presented to the Academy by him. Th Canoe was found, during drainage operations, in the Castlebar Lak or Lough Ruadh; it lay under a pile building like those frequentl found in the Swiss Lakes, but peculiar in having traces of cyclope building around the piles; it was originally 32 feet long, but abo 6 feet of what was the prow has decayed. Two much smaller Cano were found at the same time, and one still remains *in situ*, but n accessible without great labour. Flint arrow and spear heads, an a sharp bone tool, were in the Canoe when raised.

The thanks of the Academy were voted to Captain Dunne fo the Donation.

Dr. Macalister exhibited the Mummy of Tes-net-per, daughter o Tefnecht, a priestess of Neith, probably of the twenty-first dynasty and read an account of the Inscriptions. By permission of Lor James Butler, the Mummy case was exhibited, and the special thank of the Academy were accorded to his Lordship.

The Secretary read the list of Donations, and the thanks of the Academy were accorded to the respective Donors.

On the Academy proceeding to private business, the President made a statement regarding the action of the Council of the Academy in relation to the proposed Charter for the Royal Dublin Society.

The Rev. The Provost of Trinity College expressed his concurrence in the action of the Council.

MONDAY EVENING, FEBRUARY 12, 1883.

SIR SAMUEL FERGUSON, Q.C., LL.D., President, in the Chair.

Mr. J. F. Knott, F.R.C.S.I., and Mr. T. H. Longfield were elected Members of the Academy.

The President made a statement regarding the conference held this day, in the presence of His Excellency the Lord Lieutenant, on the subject of the New Science and Art Museum.

The President, having requested Dr. Frazer to take the Chair, proceeded to read his Paper "On the Inscription at Kenfig, Glamorganshire."

The President having taken the Chair, the Secretary read for Mr. Thomas Bayley a Paper "On Suggestions on the Development of the Cyclic Law of the Chemical Elements."

The Secretary read the list of Donations, and the thanks of the Academy were accorded to the Donors.

MONDAY EVENING, FEBRUARY 26, 1883.

SIR SAMUEL FERGUSON, Q.C., LL.D., President, in the Chair.

Professor William M. Hennessy delivered his first Todd Memorial Lecture for the present Session "On the Irish Element in other Languages, especially English."

Rev. T. Olden read a Paper "On the Geography of Ross Ailithir."

Mr. W. F. De Vismes Kane read a Report "On the Entomology of Lough Oughter and the Favour Royal District."

Dr. Macalister read a "Paper "On the Morphology of Joints."

The Secretary read for Mr. G. H. Kinahan a Paper "On Inscribed Stones in Co. Donegal."

The Secretary read the list of Donations, and the thanks of the Academy were accorded to the respective Donors.

The following Scientific Grants, recommended by the Counc were confirmed:—

£50 to Dr. Doberck for a Magnetic Survey of Ireland.

£10 to Dr. Cameron for Researches on the Iodates and Bromat of the Alkaloids.

£30 to Mr. H. C. Hart for the continued Botanical Examinati of the Mountains of Ireland.

Friday Evening, March 16, 1883.

(Eve of St. Patrick's Day.—Stated Meeting.)

Sir Samuel Ferguson, q.c., ll.d., President, in the Chair.

The Ballot for Members of Council was declared open, and D Wright and Mr. Longfield were requested to act as Scrutineers.

The President made a statement with regard to the result of t Conference on the site of the New Museum and Library, and read letter from the Under-Secretary to the Lord Lieutenant, announci that the Lords of the Treasury had agreed to the proposition of t enlarged site in Kildare-street.

The President also read a letter from the Under-Secretary to t Lord Lieutenant, stating that in case the Ashburnham Collection purchased by the Government, His Excellency will communicate wi the Lords Commissioners of the Treasury with regard to the depositi of the Irish Manuscripts in a Dublin Library.

The Ballot for Honorary Members was declared open, and D Sigerson and Mr. More were requested to act as Scrutineers.

The Secretary of Council read the Report for the past year, whi was adopted.

Report of the Council for the Year 1882–83.

Since the date of the last Report of the Council the followi Parts of the *Transactions* have been published:—

Vol. xxviii.—*Science.*

Part 8. "On some hitherto undescribed Compounds of Selenium By Charles A. Cameron, m.d., and Edmund W. Davy, m.d.

Part 9. "Certain Problems in the Dynamics of a Rigid System moving in Elliptic Space." By Robert S. Ball, LL.D., F.R.S.

Part 10. "On some Deductions from MacCullagh's Lectures on Rotation." By Francis A. Tarleton, LL.D., F.T.C.D.

Part 11. "On certain Definite Integrals." By John C. Malet, M.A., F.R.S.

Part 12. "On the Embryology of the Mammalian Muscular System. No. 1.—The Short Muscles of the Human Hand." By Bertram C. A. Windle, M.B., B.CH.

Vol. xxvii.—*Polite Literature and Antiquities.*

Part 5. "On Sepulchral Cellæ." By Sir Samuel Ferguson, Q. C., LL. D.

The following Part of the *Transactions* is in the Press, and will be published immediately:—

Vol. xxviii.—*Science.*

Part 13. "Report on the Acanthology of the Desmosticha." Parts ii., iii. By H. W. Mackintosh, M.A.

Of the *Proceedings*, part 8 of vol. iii. (Second Series) was published in May, 1882, and part 9 in December, 1882, both containing Papers on Science; and part 4 of vol. ii. (Second Series), containing Papers on Polite Literature and Antiquities, was published in January, 1883.

The contributors in the Department of Science are:—Dr. Reynolds; Mr. J. C. Malet; Dr. Davy; Mr. G. A. Kinahan; Mr. H. C. Hart; Dr. King; Mr. H. W. Mackintosh; Mr. J. L. E. Dreyer; Rev. W. S. Green; Dr. Macalister; Mr. B. C. A. Windle; Mr. J. F. Knott; Dr. Ball; Rev. J. Pearson; Mr. T. Bayley; Mr. W. F. De V. Kane.

In the Department of Polite Literature and Antiquities:—Sir Samuel Ferguson, President; Dr. Ingram; Mr. G. H. Kinahan; Mr. W. B. Smythe; Mr. J. R. Garstin; Mr. T. Drew; Miss Stokes; Dr. Frazer; Rev. J. B. Berkeley Barter; Professor V. Ball; Dr. Macalister; Rev. T. Olden; and the Todd Professor, Mr. William Maunsell Hennessy.

The following Grants in aid of the Preparation of Scientific Reports have been sanctioned by the Academy:—

£25 to Mr. Gerrard A. Kinahan in aid of Researches in the Minerals of Ireland by means of washing.

£25 to Dr. E. W. Davy in aid of Researches in the Physical and Chemical Properties of the Alkaloids.

£15 to Mr. H. C. Hart for Exploration of the Botany of the Coast Line of Ireland.

£20 to Messrs. F. P. Balkwill and J. Wright in aid of further Researches in the Foraminifera of Dublin Bay.

£25 to Dr. Macalister to purchase Skulls of the Peninsular and Insular Races of Western Europe, for comparison with Irish Crania.

£50 to Dr. Doberck for a Magnetic Survey of Ireland.

£10 to Dr. Cameron for Researches on the Iodates and Bromates of the Alkaloids.

£30 to Mr. H. C. Hart for the continued Botanical Examination of the Mountains of Ireland.

During the present year the Academy's Todd Professor delivered his first series of Lectures, which are now in the Press, and will be published shortly.

The Council regret that the Very Rev. Dean Reeves, Editor of the *Annals of Ulster*, has found himself compelled to resign the editorship of that work, owing to the state of his health and the pressure of official and other duties, but the Council have taken steps to carry out the publication of that important work by forwarding to the Government, with the hearty concurrence of Dean Reeves, the name of an eminent Irish scholar, Mr. Hennessy, the Academy's Todd Professor of the Celtic Languages, as the proposed Editor of the Annals.

During the present year about eighty pages of the *Book of Ballymote* have been photographed, sixty-six additional pages have been printed off, and one hundred pages are in a forward state of preparation, so that the anticipation of the preceding Report has been fairly met.

The additions to the collections in the Museum, acquired by purchase within the past year, comprise about two hundred objects, chiefly in flint and bronze.

The Donations, during the same period, consist of a series of prehistoric implements from Banda, N. W. Provinces of India; an ancient Irish harp; a unique spinning machine of wood; portion of a massive gold-plated unclosed ring, with rude archaic markings; and a canoe, found during the drainage operations in Lough Ruadh, in the vicinity of Castlebar.

A valuable contribution to our Library has been made by the Earl of Charlemont, who has liberally presented the collection of papers and letters of his predecessor, James Earl of Charlemont, the first President of this Academy.

As it was felt by the Council that the site for the proposed new National Museum in Kildare-street, and the plans drawn in accordance therewith, were unsuitable for the purposes for which they were intended, the Council forwarded to His Excellency a Resolution, with a detailed statement of their objections, and they are happy to report that the concurrent action of the Council and the other important bodies prevailed with the Irish Government; and representatives from the Academy and the other public bodies were accordingly summoned to the Castle, for the purpose of conferring with His Excellency on the subject. The result of this conference was the concession by the Government that an enlarged site should be obtained, and competition invited for suitable plans for the proposed new Museum under the new conditions of enlarged site. In this respect the Council cannot too strongly express their thanks to Earl Spencer for his large-minded willingness to consult and give weight to the enlightened opinion of the community.

It having been brought under the notice of the Council that a proposed New Charter had been prepared for the Royal Dublin Society, the Council, after examination of the proposed Charter, adopted the following Resolution :—

"That, in the opinion of this Council, the Draft Supplemental Charter of the Royal Dublin Society, which will be laid before the Meeting of that Society on the 18th inst., will (if confirmed) be highly prejudicial to the interests of the Royal Irish Academy; and this Council is prepared to offer to the final confirmation of such a Charter its strenuous opposition."

In consequence of the Charter's not having passed at the meeting of the Royal Dublin Society, it became unnecessary for the Council to take any further action in the matter.

The following Ordinary Members have been elected since the 16th March, 1882 :—

1. R. J. Mahony, D.L.
2. F. J. O'Farrell, F.C.S.
3. Rev. H. R. Collum, F.S.S.

4. F. H. Houston, F.R.G.S.I.
5. J. F. O'Reardon.
6. T. Greer, M.P.
7. J. F. Knott, F.R.C.S.I.
8. T. H. Longfield.

We have lost by death within the year one Honorary Member— Henry John Stephen Smith, F.R.S.

And nine Ordinary Members :—

1. Right Hon. Lord Castletown of Upper Ossory, elect January 13, 1873.
2. Samuel F. Downing, LL.D., elected February 11, 1856.
3. Gerald FitzGibbon, M.A., elected April 12, 1841.
4. William Digges La Touche, M.A., elected January 25, 18
5. Denis Florence MacCarthy, elected April 13, 1857.
6. Right Hon. Sir Joseph Napier, Bart., LL.D., D.C.L., elect February 10, 1840.
7. Standish G. Rowley, LL.D., elected April 8, 1872.
8. Evelyn Philip Shirley, M.A., elected January 13, 1873.
9. Walter Sweetman, J.P., elected February 24, 1845.

Such a Report as this is not the place in which justice can be do to the poetical merits of Mr. D. F. Mac Carthy, which have receiv ample appreciation in the literary world. Many of his fresh a graceful lyrics live in all our memories; and his translations of t Plays of Calderon, in which he attempted the difficult task of repr ducing in English the Spanish assonant rhyme, have met with highly favourable judgment from such competent authorities as Lon fellow and Ticknor. The principal events of Mr. Mac Carthy's li with the titles and dates of his publications, are given in the prefa to a very attractive volume, lately published by his son, containi most of his original poems. He contributed to our *Proceedings*, 1862, a Paper in relation to the MS. of the Memoirs of the Court Spain, ascribed to the Marquis de Villars.

Samuel F. Downing, LL.D., was for many years Professor of Eng neering in Trinity College. He was the author of *Elements of Practic Hydraulics*, of which a second edition appeared in 1861, and a thi was in preparation at the time of his death. In the Academy *Transactions* will be found a Paper of his "On the Drainage Haarlem Lake."

The Secretary of the Academy proposed, and Dr. Ingram seconded, that

The President,
Sir Robert Kane, and
Rev. The Provost of Trinity College

be re-elected as the Academy's Representatives on the Board of Visitors of the National Museum.

The Resolution was carried.

Dr. Stokes proposed, and Mr. Leonard seconded, the following Resolution:—

"That Council be requested to inform the Academy what steps, if any, have been taken by Council in relation to the proposed New Charter for the Royal Dublin Society, and to state its opinion as to the probable effect of such Charter on the status and interests of the Academy."

Dr. Ingram proposed, and Dr. Tarleton seconded, as an Amendment:—

"That it is expedient to postpone any expression of opinion as to the proposed New Charter of the Royal Dublin Society until the terms of that Charter have been made public."

The Amendment was carried.

The Scrutineers having reported, the President declared the result of the Ballot for President and Council as follows:—

PRESIDENT.

SIR SAMUEL FERGUSON, Q.C., LL.D.

COUNCIL.

Committee of Science.

Rev. Samuel Haughton, M.D., F.R.S., S.F.T.C.D.
Edmund W. Davy, M.A., M.D.
J. P. O'Reilly, C.E.
Alexander Macalister, M.D., F.R.S.
John Casey, LL.D., F.R.S.
F. A. Tarleton, LL.D., F.T.C.D.
George Sigerson, M.D.
Charles R. C. Tichborne, PH.D.
Sir Robert Kane, LL.D., F.R.S.
Rev. J. H. Jellett, D.D.
Alexander G. More, F.L.S.

John Kells Ingram, LL.D., F.T.C.D.
William Frazer, F.R.C.S.I.
David R. Pigot, M.A.
T. N. Deane, R.H.A.
William M. Hennessy, Esq.

The Scrutineers having reported,

Professor Charcot, of Paris, and
John Evans, D.C.L., Treasurer, Royal Socie

were elected Honorary Members of the Academy.

The Ballot for Officers was declared open, an
Dr. Tarleton were requested to act as Scrutineers

The Secretary read the list of Donations, and
Academy were accorded to the respective Donors.

The President, under his hand and seal, appoir
Vice-Presidents for 1883–84 :—

Rev. Samuel Haughton, M.D.
John Casey, LL.D.
Very Rev. William Reeves, D.D.
David R. Pigot, M.A.

The Scrutineers reported the election of the foll

TREASURER.—Rev. M. H. Close, M.A.

Royal Irish Academy.

GENERAL ABSTRACT OF THE ACCOUNTS,

FROM

1st April, 1881, to 31st March, 1882.

[illegible]

Appropriations —

Preparation of Scientific Reports. [illegible]

Library [illegible]

[illegible] in connection with [illegible] [illegible]

Publication of data. [illegible]

Museum. [illegible]

Purchase of [illegible] [illegible]

Illustration and Printing of "Transactions" and "Proceedings" [illegible]

Lighting the museum in the evening [illegible]

. SCIENCE GRANT [illegible] [illegible]

. MEMBERS' PAYMENTS —

Entrance Fees.

Annual Subscriptions.

Life Membership Compositions [illegible] [illegible]

. PUBLICATIONS SOLD —

Transactions.

Proceedings.

[illegible]

[illegible]

[illegible]

[illegible] [illegible]

ADEMY.

LOSE, TREASURER OF THE ROYAL IRISH ACADEMY,

MARCH, 1882.

PAYMENTS.	From Funds appropriated for Special Purposes.	From Funds available for General Purposes.	Total of each Class.
	£ s. d.	£ s. d.	£ s. d.
OR SCIENTIFIC AND LITERARY PURPOSES:—			
Polite Literature and Antiquity Objects,	. . .	. . .	
Scientific Reports,	217 10 11	. . .	
Library,	200 0 0	151 11 7	
Irish Scribe, &c.,	200 0 0		
" (including Photo-Lithographing of Book of Ballymote),	200 0 0		
Museum,	200 0 0	25 3 0	
Treasure Trove	100 0 0	98 16 6	
"Transactions" and "Proceedings,"	200 0 0	69 16 2	
Opening the Academy in the evening,	200 0 0	6 10 8	
Cunningham Medal,	21 0 0		
" Prize Memoir,	29 17 10		
			1920 6 8
" ESTABLISHMENT CHARGES:—			
Salaries,	. . .	334 4 11	
Wages and Liveries,	. . .	196 7 6	
Furniture and Repairs,	. . .	17 11 3	
Fuel,	. . .	42 8 3	
Insurance, Taxes, and Law,	. . .	10 12 11	
Stationery,	. . .	9 1 4	
Printing (Miscellaneous),	. . .	27 12 9	
Postage,	. . .	25 0 0	
Freights, Incidentals, and Contingencies,	. . .	43 11 4	
			706 10 3
" INVESTMENTS (CAPITAL):—			

	Stock Bought.	Description.	Total Stock.
	£ s. d.		£ s. d.
fe Membership Compositions,	62 5 9	Consol. Stock,	2900 11 0
useum Catalogue,	2 17 1	Bk. of Ir. Stock,	53 3 0

	From Funds appropriated for Special Purposes.	From Funds available for General Purposes.	Total of each Class.
fe Membership Compositions	63 0 0		
useum Catalogue	9 6 11		
			72 6 11
" TEA FUND Expenditure,	5 5 0	11 15 1	17 0 1
	£1646 0 8	1070 3 3	2716 3 11
Balance to Credit of the Academy,	96 19 5	91 5 0	188 4 5
	£1743 0 1	1161 8 3	2904 8 4

AUDITORS' REPORT.

We have examined the above General Abstract, and compared the Vouchers fo the details of the several heads thereof, and find the same to be correct, leaving a Balance of One Hundred and Seventy-three Pounds Nine Shillings and Eight Pence to the credit of the Academy, the amount certified by the Accountant-General as standing to the credit of the Academy's account in the Bank of Ireland on the 31st of March, 1882, being £237 14*s.* 2*d.*, cheques amounting to £64 4*s.* 6*d.*, having remained unpresented.

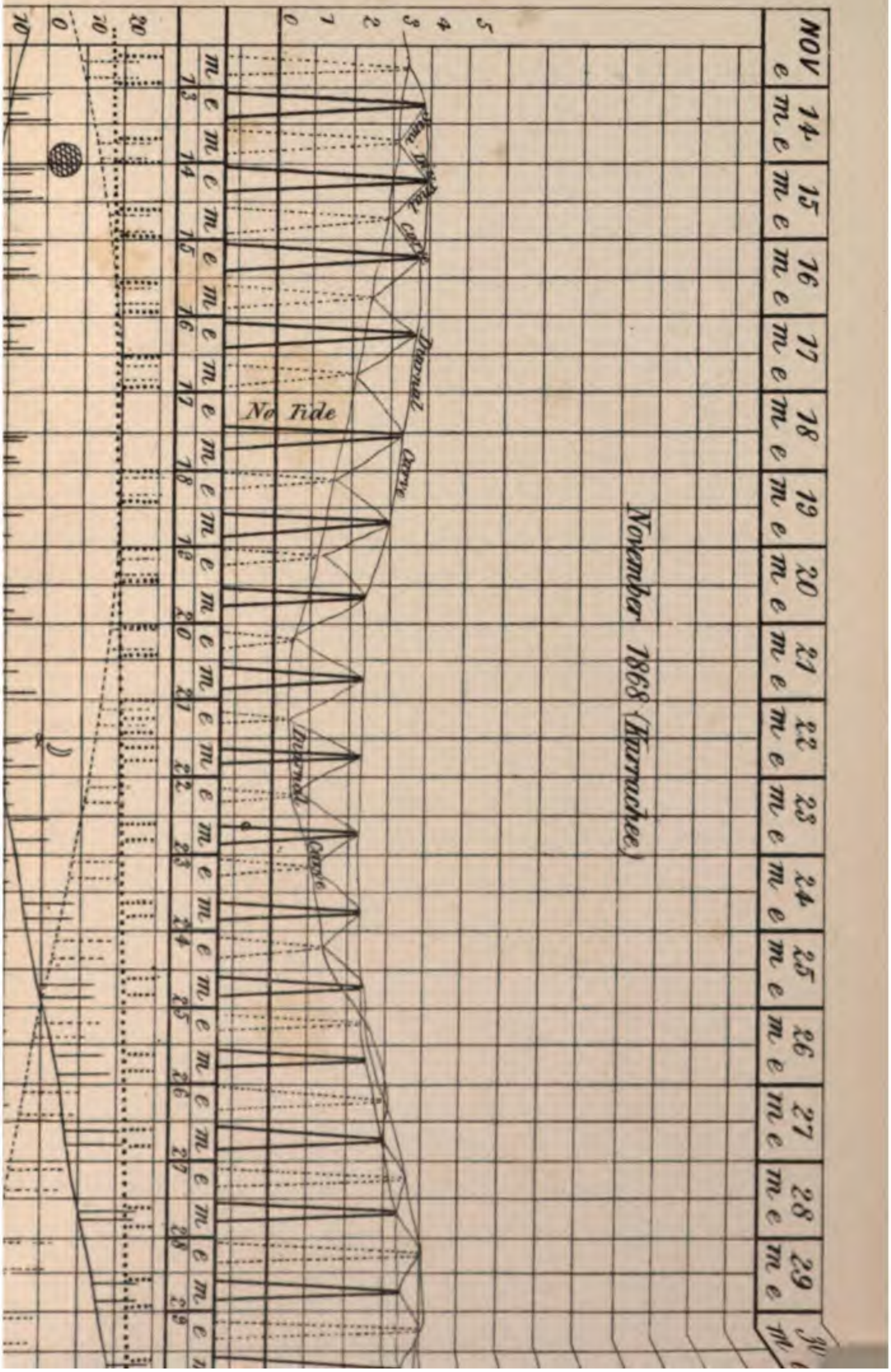
The Treasurer has also exhibited to us Certificates in respect of the invested *Capital*, showing that the amounts of Stock standing in the name of the Academy on the same day were £2653 9*s.* 9*d.*, New Three per cents.; £2936 8*s.* 10*d.*, Consols; and £55 18*s.* 7*d.*, Bank of Ireland Stock.

(Signed), { WILLIAM FRAZER, JOHN CASEY, } *Auditors.*

21*st April*, 1883.

TODD MEMORIAL FUND.

This Fund consists of two sums, both invested in New Three per Cents., viz £1209 18*s.* 4*d.* standing in the name of the Accountant-General of the Court of Chancery, and £142 2*s.* 4*d.* (composed of a conditional subscription and accru income added thereto) standing in the joint names of Mr. J. T. Gilbert and Rev M. H. Close.


NOV
14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
November 1868 (Kurrachee)
No Tide
Diurnal Curve
Curve

Proc. R.I.A. Plate XXI.